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ARS Grain Crop Production and Quality Review

St. Louis, Missouri
May 6-10,1991

A R S

GRAIN CROP

PRODUCTION AND QUALITY

REVIEW

St. Louis, Missouri

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ARS GRAIN CROP

PRODUCTION AND QUALITY

REVIEW

ST. LOUIS, MISSOURI

MAY 6-10, 1991

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AGENDA

ARS GRAIN CROP PRODUCTION AND QUALITY RESEARCH REVIEW

AIRPORT MARRIOTT, ST. LOUIS, MISSOURI
MAY 6-10, 1991

MONDAY, MAY 6, 1991

7:30 a.m.	Continental Breakfast	
8:00 a.m.	Introductions	C. F. Murphy
8:15 a.m.	Overview	C. F. Murphy
8:45 a.m.	Germplasm Preservation, Evaluation, and Quarantine	Panel: Wesenberg, Chm., Dilday, Schertz
10:15 a.m.	B R E A K	
10:30 a.m.	Discussion	
12:00 noon	L U N C H	
1:15 p.m.	Germplasm Enhancement and Breeding	Panel: Allan, Chm., Wesenberg, Webb, Vogel
3:15 p.m.	B R E A K	
3:30 p.m.	Discussion	
5:00 p.m.	Adjourn	
7:00 p.m.	D I N N E R	

TUESDAY, MAY 7, 1991

7:30 a.m.	Continental Breakfast	
8:00 a.m.	Cytogenetics and Wide Hybrids	Panel: Williams, Chm., Schertz, Wesenberg
9:00 a.m.	Discussion	
10:00 a.m.	B R E A K	
10:15 a.m.	Molecular Biology and Tissue Culture	Panel: Pring, Chm., Mattoo, Scharen, Rines
11:45 a.m.	L U N C H	
1:00 p.m.	Discussion	
2:45 p.m.	B R E A K	
3:00 p.m.	Stress Physiology	Panel: Olien, Chm., Livingston, Vogel, Banowitz
4:00 p.m.	Discussion	
5:00 p.m.	Adjourn	
7:00 p.m.	D I N N E R	

WEDNESDAY, MAY 8, 1991

7:30 a.m.	Continental Breakfast	
8:00 a.m.	Control of Cereal Rusts	Panel: Leonard, Chm., Eversmeyer, Roberts
9:00 a.m.	Discussion	
10:00 a.m.	B R E A K	
10:15 a.m.	Control of Other Foliar Fungal Diseases and Root Diseases	Panel: Dunkle, Chm., Leath, Pring, Dowler, Cook
11:45 a.m.	L U N C H	
1:00 p.m.	Discussion	
3:00 p.m.	B R E A K	
3:15 p.m.	Control of Virus Diseases	Panel: Hewings, Chm., Gray, Vogel
4:15 p.m.	Discussion	
5:30 p.m.	Adjourn	
7:00 p.m.	D I N N E R	

THURSDAY, MAY 9, 1991

7:30 a.m.	Continental Breakfast	
8:00 a.m.	Control of Insect Pests	Panel: Burton, Chm., Webb, Ratcliffe, Eversmeyer
9:00 a.m.	Discussion	
10:00 a.m.	B R E A K	
10:15 a.m.	Understanding Genetic, Physical, Biochemical, and Nutritional Components Impacting Quality in Cereal Crops	Panel: Betschart, Chm., Greene, Peterson, Webb
11:45 a.m.	L U N C H	
1:00 p.m.	Discussion	
2:30 p.m.	B R E A K	
2:45 p.m.	Quality Evaluation	Panel: Smail, Chm., Finney, Peterson, Webb
3:45 p.m.	Discussion	
5:30 p.m.	Adjourn	
7:00 p.m.	D I N N E R	

FRIDAY, MAY 10, 1991

7:30 a.m.	Continental Breakfast	
8:15 a.m.	Executive Session	(Industry Reviewers, Area Directors, and NPLs)
9:45 a.m.	B R E A K	
10:00 a.m.	Wrap-Up Session Report from Industry Reviewers	
11:30 a.m.	Final Adjournment	

INTRODUCTION

The ARS Grain Crop Production and Quality Review was a major event in an ongoing series of activities designed to assure the relevance of ARS grain crop research to current and projected needs. Because a similar review of corn research had been conducted just two years previously, this Review was limited to production and quality research on wheat, oats, barley, rice, and sorghum. The Review itself represented the third of a four-step process, as follows:

1) New ARS Cereal Scientists Workshop

2) Summaries of ARS production and quality research on wheat, oats, barley, rice, and sorghum

3) ARS Grain Crop Production and Quality Review

4) Implementation

NEW ARS CEREAL SCIENTISTS WORKSHOP

About one-third of the scientists working in the areas of grain crop production and quality have initiated their programs within the past five years. They represent a range of scientific backgrounds and their commodity responsibilities vary. Nevertheless, they are addressing related problems and utilizing often related methodologies.

The New ARS Cereal Scientists Workshop brought together 37 *"new"* ARS researchers and two new cereal scientists from the host university *(the University of Idaho)* for a three-day workshop in Pocatello, Idaho, May 22-24, 1990. Each participant presented a five-minute summary of his or her program and submitted a one-page program summary, which was included in the Workshop report. The participants also toured the new ARS Small Grains Germplasm Research Facility at Aberdeen, Idaho, and heard a presentation on the History of ARS Cereal Crops Research by Dr. E. L. Kendrick. The final day was devoted to pre-assigned break-out groups addressing topics as follows:

Improving Value-Added Traits

- Fiber Characteristics
- Wheat Quality for the Future
- Specialty Traits

Protecting Plants from Pests and Pathogens

- Cereal Viruses
- Fungal Diseases
- Cereal Insects

- Genetics of Resistance

Yield Efficiency and Breeding Methodology

- Stress Tolerance and Senescence
- Gene Transfer Technology
- Gene Mapping
- Breeding Methodology and Cytogenetics

A product *(included in the Workshop Report)* was generated for each sub-topic which addressed objectives, as follows:

1) **Identify priority research areas**

2) **Identify research needs and approaches**

3) **Identify new and/or potential cooperative links to more effectively carry out this research.**

Summaries of ARS Production and Quality Research on Grain Crops

A follow-up activity to the ARS Corn Production Research Review *(May 16- 17, 1989)* was the preparation of an Addendum Report which provided a summary of corn production research. This report proved so useful that similar reports were generated for wheat, oats, barley, rice, and sorghum. These reports were distributed in September 1990, in preparation for the ARS Grain Crop Production and Quality Review.

The information for these individual crop summaries was generated from material submitted by individual locations. That information was then combined and presented in two sections, as follows:

Program Objectives

A summary of program objectives and sub-objectives along with a listing of major achievements within each sub-objective and the impact of these achievements on science and/or technology

Resource Deployment

A deployment of resources *(net-to-location)* between objectives *(usually about 12)* is estimated for the participating locations in matrix format.

ARS Grain Crop Production and Quality Review

This Review was not intended to cover all ARS research on wheat, oats, barley, rice, and sorghum. The two most notable research areas not covered relate to production systems

and post-harvest storage and utilization. Individual projects were not always examined to the same depth as might be expected during an in-depth location review but, nevertheless, the Review did, as intended, look at program areas by examining the objectives and approaches of individual investigators and projects. All participants were asked to address these *(and similar)* questions:

- ☼ Are resource allocations appropriate *(especially to problem areas within commodities)*?
- ☼ Are there problems which are not being addressed or which deserve more attention?
- ☼ Are there problems which are receiving too much attention?
- ☼ Is the quality of the programs sufficient to anticipate progress?

IMPLEMENTATION

The information summarized in the above listed activities and the formal recommendations generated during both the Pocatello and St. Louis meetings will provide a foundation for action during the coming months and years. Primary responsibility for these implementation actions will fall to the National Program Staff but successful implementation will require close cooperation and liaison with Area Directors, Research Leaders, and industry leaders.

THE REVIEW

FORMAT

Programs to be included in the Review were identified in 38 ARS management units (MU's) at 31 locations. Invited participants included a representative of each of these MU's, all ARS Area Directors, seven National Program Leaders, and eight industry representatives, who were asked to serve as a review team.

Eleven panels were assigned to discuss individual research areas which were arbitrarily designated to provide a convenient structure for the program Review. Each of the 38 identified MU's *(or a researcher therein)* was identified for review by one, or more, of the panels. The eleven designated research areas were:

- Germplasm Preservation, Evaluation, and Quarantine
- Germplasm Enhancement and Breeding
- Cytogenetics and Wide Hybrids
- Molecular Biology and Tissue Culture
- Stress Physiology
- Control of Cereal Rusts
- Control of Other Foliar Fungal Diseases and Root Diseases
- Control of Virus Diseases
- Control of Insect Pests
- Understanding Genetic, Physical, Biochemical, and Nutritional Components Impacting Quality in Cereal Crops
- Quality Evaluation

In order to assist the Review participants, and the readers of this report, graphics were prepared which provide an approximate allocation of resources *(dollars and people)* within and between research areas and commodities. The visuals proved to be a valuable resource during the Review and they are included herein *(Appendix A)*. They are presented with the following caveats:

- Dollar figures are net-to-location as of several weeks prior to the Review;

- Allocations to commodity reflect CRIS commodity coding;

- Allocations between research areas are strictly arbitrary and intended only to facilitate the Review procedure; and

- Data sets may include minor inaccuracies.

One-page summaries of research *(by commodity)* within each MU were prepared and distributed to participants prior to the Review. These summaries are included herein *(Appendix B)*.

Eight industry representatives participated in the Review. These individuals were asked to form a Review Team and report their observations/recommendations to the participants and to present a report for inclusion in this document. Dr. Mike Davis served as Chair of this Team. Their concensus based report follows.

COMMENTS

AND

RECOMMENDATIONS

from

A R S

GRAIN CROP

PRODUCTION AND QUALITY REVIEW

ST. LOUIS, MISSOURI

MAY 6-10, 1991

Prepared by:
Mike Davis, Chm.
Jim Christiansen
Gene Dalton
Ian Edwards
Jim Stroike
Richard Stuckey
Fran Webster
Sam Weaver

Report of Industry Review

Opening Remarks

We would like at the outset to thank the Agricultural Research Service (ARS), Dr. Murphy, and the National Program Staff for the opportunity to serve on the Industrial Review Team. It has been a stimulating week and we are impressed by the overall quality of the research, the scope and breadth of the investigations, and the way in which very limited project funds have been stretched to deliver the best possible results. For these things, we feel that we must congratulate the Administrator, the National Program Staff and the Area Directors for their leadership and the researchers for their dedication.

Having said this, we offer the following general comments.

1. Firstly, the ARS needs to be a leader and an innovator in agricultural research. It must communicate a clear sense of mission, and it must articulate where research priorities should be in the years ahead. It must be drawn by a vision—not driven by a budget into *"plugging gaps"* that are seen to occur in other public research! This may necessitate some major shifts in emphasis from time-to-time, and this will not be easy to implement. However, the ARS needs to look to the future and be willing to pursue the new technologies that many of its scientists are now uncovering with very limited budgets.

2. The benefits that are obtained from locating ARS scientists at State Experiment Stations has been evident over the years.

3. We further recommend that the recognition and reward system in the ARS be reviewed. The ARS receives the thanks and respect of the agricultural community at large for such service functions as quality evaluation, regional and international nurseries, and the preservation of genetic stocks. We feel that the scientists responsible should be recognized and rewarded.

4. It was clear to the committee that a major priority should be the development of a small grains transformation system, i.e., for wheat, barley, oats, sorghum and rice. This will take a very focussed commitment, but without it there will always be the temptation to adhere to a model system where new knowledge can be pursued. We need both, and we need to have the ARS committed to technology transfer in those crops that will not be receiving private sector and other sources of funding. Barley yellow dwarf virus (BYDV) is a classic example of where we need a focussed effort on a disease of great economic importance.

5. The Genetic Resources Information Network (GRIN) system needs further

examination. Why is it not being used extensively? Is it really *"user friendly."* The Crop Advisory Committees (CAC's) should be called on for further support and a concerted effort should be made to prioritize the functions and get more information loaded. A much wider communication is needed to encourage user support.

6. At times of severe budgetary restrictions we feel that it is important for the ARS to maintain a national focus. There are certainly some regional problems to be addressed but there is also a very parochial attitude in some instances and this is a *"luxury"* the ARS cannot afford. As an example, a wide crosses program should be of national scope.

7. Cereal quality requires better definition. What is quality in each of our crops? What is quality in the different classes of wheat? We heard the constant call for researchers to consider quality when they deploy germplasm for different tasks. When this is better defined, we are confident researchers will respond.

8. We feel this review is timely. Over the next several years a number of talented researchers will be retiring. They have made a tremendous contribution! However, do not let past successes restrict change and a new direction where appropriate.

9. Finally, it has been a challenge for our committee this week. We recognize that there are a number of CSRS and other public sector projects that complement existing ARS work. Therefore, we offer recommendations that could well have been made with limited knowledge of these other opportunities. We ask that this be borne in mind as we now review the specific sections that were presented this week.

I. Germplasm Preservation, Evaluation and Quarantine

We are pleased with the programs and efforts of the ARS in this area, given the limited available resources. We commend the ARS for its effective and timely utilization of the germplasm collections to find sources of resistance to new pests, such as the Russian wheat aphid, QCC stem rust, and barley stripe rust.

We recommend that each crop CAC reevaluate its funding allocations between quarantine, preservation, evaluation and enhancement to determine if the current allocations are appropriate.

A. Preservation Facilities

Overall, existing germplasm preservation facilities are adequate, except for rice storage at Stuttgart, Arkansas. The rice trailer storage facility should be replaced with a permanent seed storage area, as

part of the planned ARS rice research facility at this location.

B. Quarantine

Germplasm personnel need to work more closely with APHIS to ensure regulations are updated and countries and crop species are removed from the restricted list where appropriate. An example is the current limitation on the utilization of Avena sterilis germplasm because it is classed as a noxious weed.

C. Evaluation

1. GRIN

The system needs to be made more *"user-friendly"* so that it is effectively utilized by the plant breeding community. Program changes are needed to improve access of information and to ensure proper input of data. The system should accommodate quality parameters as they become available from evaluations of the collections.

2. Uniform Nurseries

We strongly support the continuation of these important nurseries. Personnel engaged in conducting these nurseries should be given professional recognition and support.

3. Core Collections

Establishment of core collections should not be made at the expense of completing the evaluations of the full collections. Once the full collection evaluations are complete, cores or subsets should be identified to aid in the distribution of specific types of germplasm. CAC's are the appropriate groups to identify such subsets or cores for their crops.

II. Germplasm Enhancement and Breeding

The Team was pleased with the activities in this area. It was, however, noted that ARS needs to be more proactive and take the lead in establishing or improving collaboration at locations where it has germplasm enhancement and/or breeding programs in association with state programs.

III. Cytogenetics and Wide Hybrids

The cytogenetics research in the ARS has not only brought international

acclaim but has provided invaluable resources to breeders of small grains. In reviewing the current status of research the review committee found the following:

A. Rice

Urgently needs a cytogeneticist to provide a base for future molecular work. We recommend Arkansas. The new facility at Stuttgart could house the cytogeneticist.

B. Oats

We recommend a cytogeneticist be based at the University of Minnesota.

C. Sorghum

Need a position at Texas A&M with Dr. Keith Schertz. Someone who can take over when Dr. Schertz retires.

D. Barley

The new appointment at Aberdeen, Idaho meets current needs.

E. Wheat

A replacement is needed for the position held by the late Dr. Sears at Columbia, Missouri. Assignment of a technician does not adequately address the genetic stocks maintenance and distribution.

IV. Molecular Biology and Tissue Culture

Model systems are critical to the development of new technologies such as transformation but small grains need to be addressed. Public sector support is vital for crops like wheat, barley, and oats in which commercial company input is very low. We recommend that the funding of $490,500 for small grain biotechnology at the PGEC be addressed and that the vice-Fromm position be dedicated to small grains transformation. The committee is concerned about the commitment of technology transfer from corn to a workable transformation system for small grains crops.

There is also an urgent need to improve communication among groups conducting molecular biology.

V. Stress Physiology

A. The committee feels that there is a great need for stress physiology research but we are concerned about the direction of the work.

B. A special concern is the work at Nebraska on sorghum stress physiology. The projects should be consolidated and redirected to agronomically useful work.

C. The wheat physiology work at Corvallis needs to be reevaluated and possibly redirected to other needs.

D. Lack of winter hardiness in oats is a major limiting factor and this worthwhile project needs to be continued. Consider moving the position to Raleigh, North Carolina, where there is a larger support team.

Disease Control

The committee found the ARS disease control staff to be of high quality, productive with resources available, and providing new knowledge and service of benefit to the small grain industry.

VI. Control of Cereal Rusts

Statement: ARS has provided adequate resources for cereal rusts, however, there is a need to examine resource allocation and the location of personnel.

Recommendations:

1. Allocation Study should include:

   - nature of virulence shifts in population
   - survival fitness of new virulence genes
   - slow rusting
   - sources of host resistance and resistance mechanisms

2. The recent importance of stem rust (QCC) and potential of stripe rust (race 24) create an urgency for a full time position for barley rust research.

3. Wide crosses programs need to be national in scope.

4. Additional funding support is needed for Griffin, Georgia, location.

VII. Control of Other Fungal and Bacterial Diseases

Statement: An understaffed area in proportion to the number and importance of the diseases included in this category. Several impending retirements provide an opportunity for realignment.

Recommendations:

1. To fill the retirement position at Montana State University with a smut/bunt pathologist. Encourage leadership role among CSRS researchers with smut/bunt programs.

2. Replace the retirement position at Texas A&M with a category 1 molecular-oriented sorghum pathologist.

3. Create a new position for a small grain pathologist at a strong wheat research and breeding program in the Southeast.

4. Pursue the hiring of a soil-borne oriented pathologist to work in a dry, cold soils climate at Mandan, North Dakota.

VIII. Control of Viral Diseases

Statement: Yield and quality losses incurred annually due to viruses of small grains are unknown and very likely underestimated. There is a need to identify and quantify those losses so appropriate management decisions can be made.

Recommendations:

1. Sponsor a small grain viruses workshop to enhance collaboration with other wheat, barley and oat researchers *(virologists, entomologists, pathologists, agronomists).*

2. Provide adequate support to evaluate barley as well as wheat and oats at Urbana.

IX. Control of Insect Pests

The outstanding work on Hessian fly and the Russian wheat aphid is recognized and commended by the review team. This quality research is only one example of the responsiveness of ARS and the capabilities within the Agency.

Recommendations:

1. Basic sorghum entomology work is required in the Great Plains.

2. Physiologist/biochemist position is needed to support the entomology research at the Stillwater location. *(Utilize funds from Gough position.)*

3. Reevaluate position description at Crowley and reassess total entomology effort on rice, including molecular approaches.

X. Genetic, Physical, Biochemical and Nutritional Components Impacting Quality in Cereal Crops

Recommendations: Top priorities relative to quality should focus on

1. Genotype x Environment interaction

2. Development of cereal transformation system

3. Nutritional quality/utilization should focus on new end product applications (not new product development).

4. In the near term, analytical methodology needs improvement.

5. Increase funding for specialty rice utilization and methodology.

XI. Quality Evaluation

The service activities of ARS scientists are recognized by the review team and their peers as well as ARS administrators. These services are so important to the advancement of collaborative research activities that a clear recognition/reward system needs to be in place.

Recommendations:

1. Load GRIN system with quality factors as defined by the CAC's.

2. At the Cereal Crops Research Unit at Madison, additional funding is needed to

    a) fill malting barley chemist position
    b) purchase NIR analyzer
    c) enable staff to perform research to meet stated objectives.

ARS should be commended for taking the lead on development of method to develop device to measure quality at point of sale. This project has reached a point where it is time to determine responsibility to complete and mass produce device and set standards for use. Should this be an ARS responsibility?

Appendix A

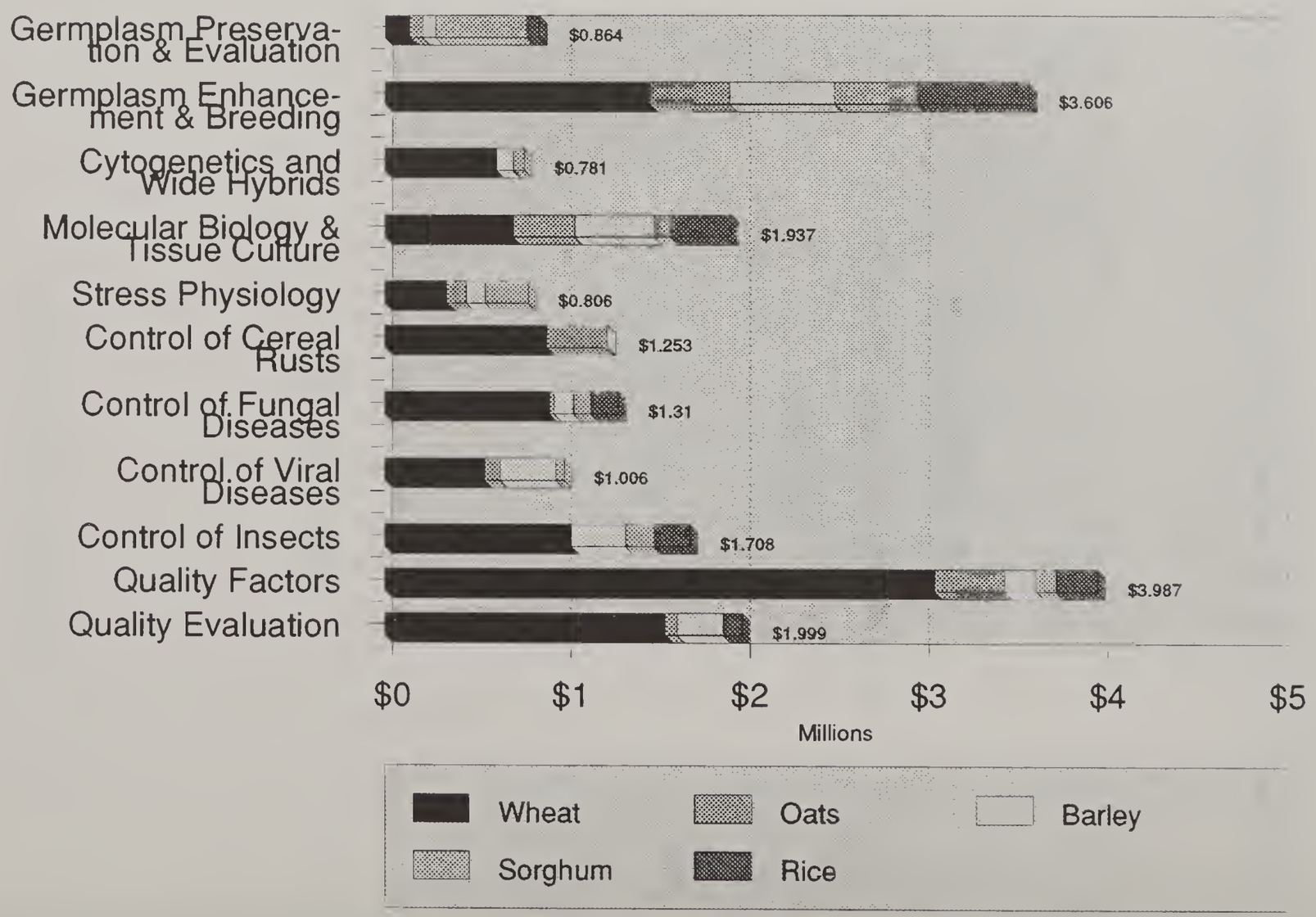
ARS GRAIN CROP PRODUCTION AND QUALITY REVIEW

ST. LOUIS, MISSOURI

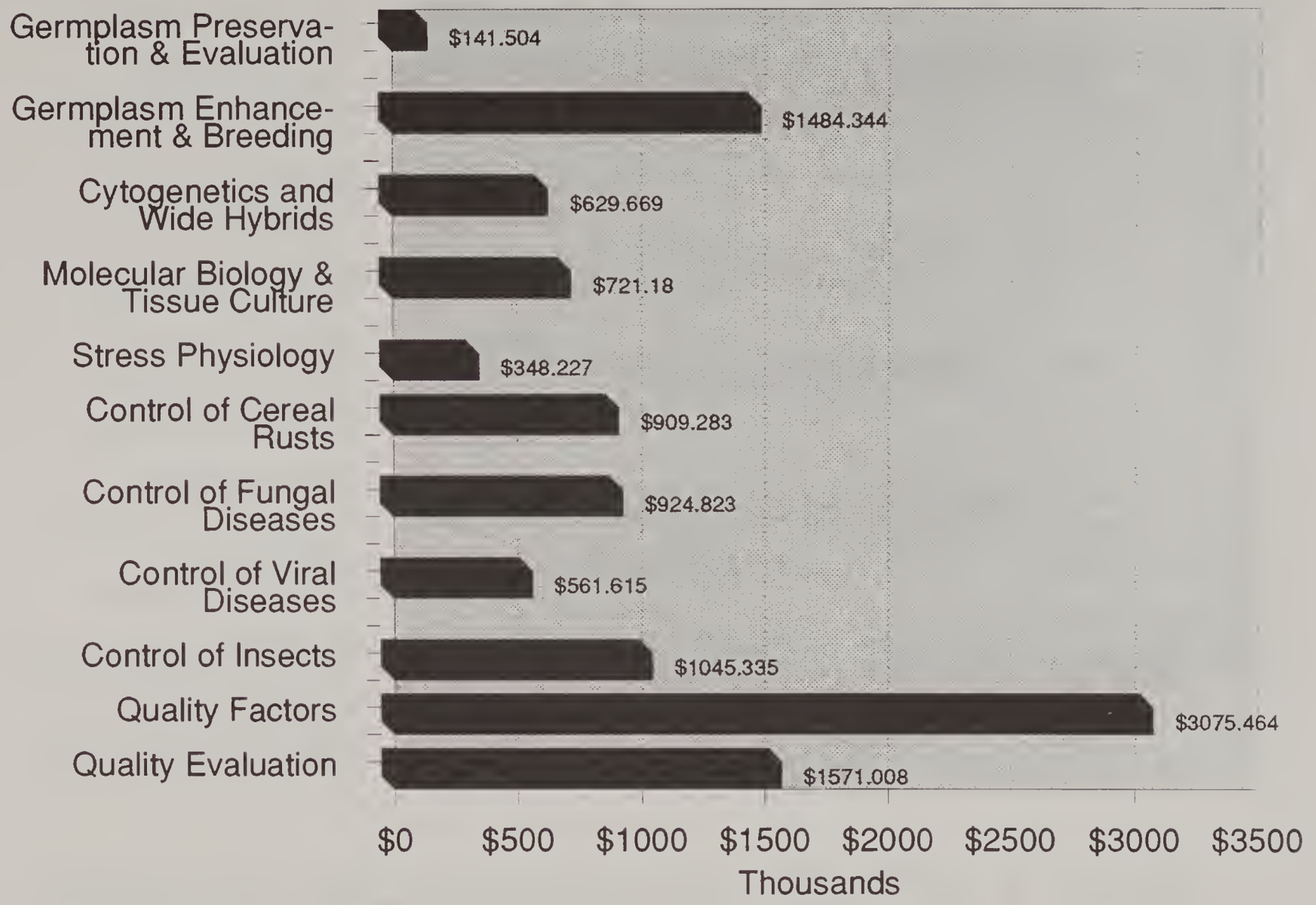
MAY 6-10, 1991

RESOURCE ALLOCATIONS

Research Dollars by Commodity

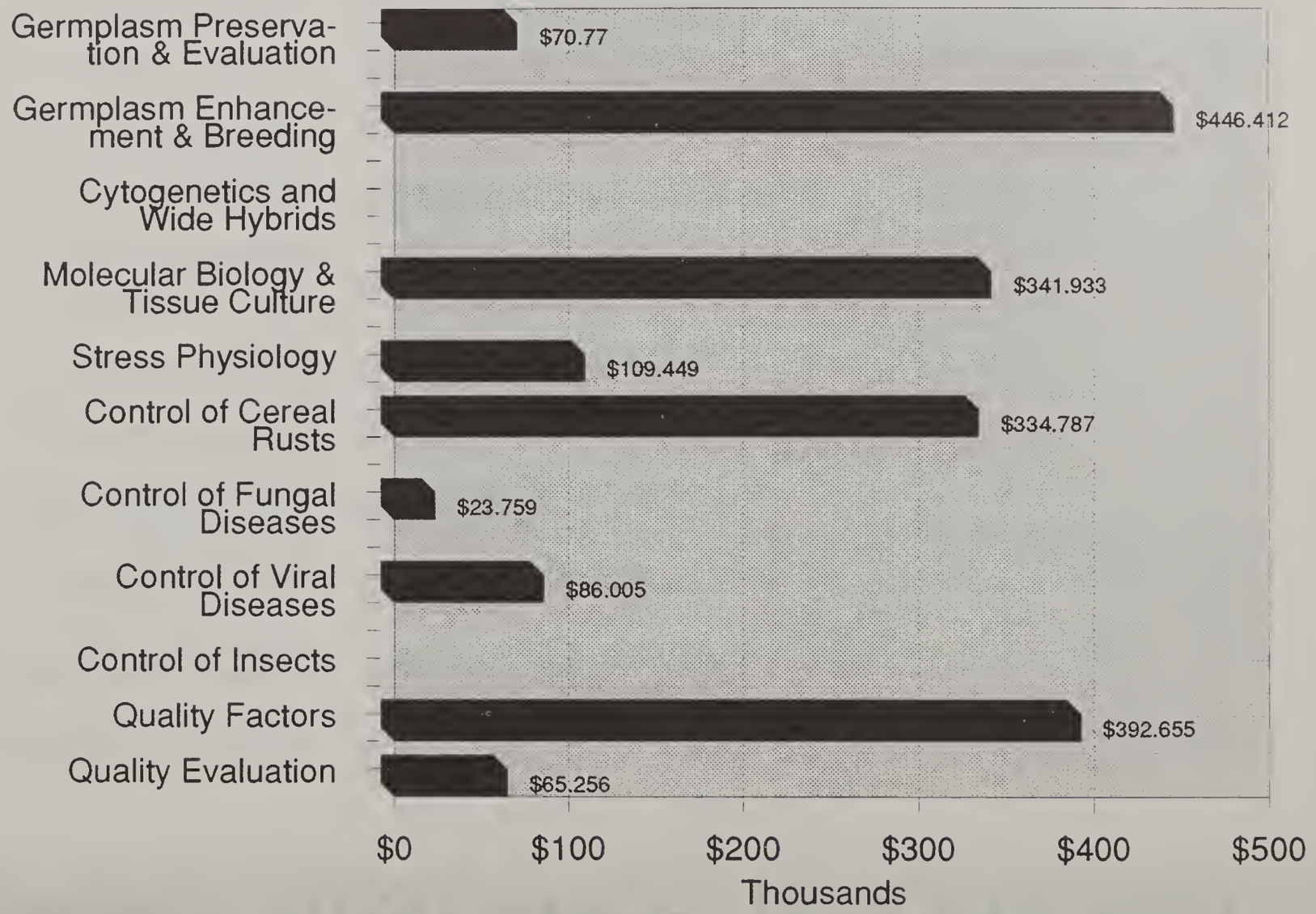


WHEAT RESEARCH ($11,412,452)

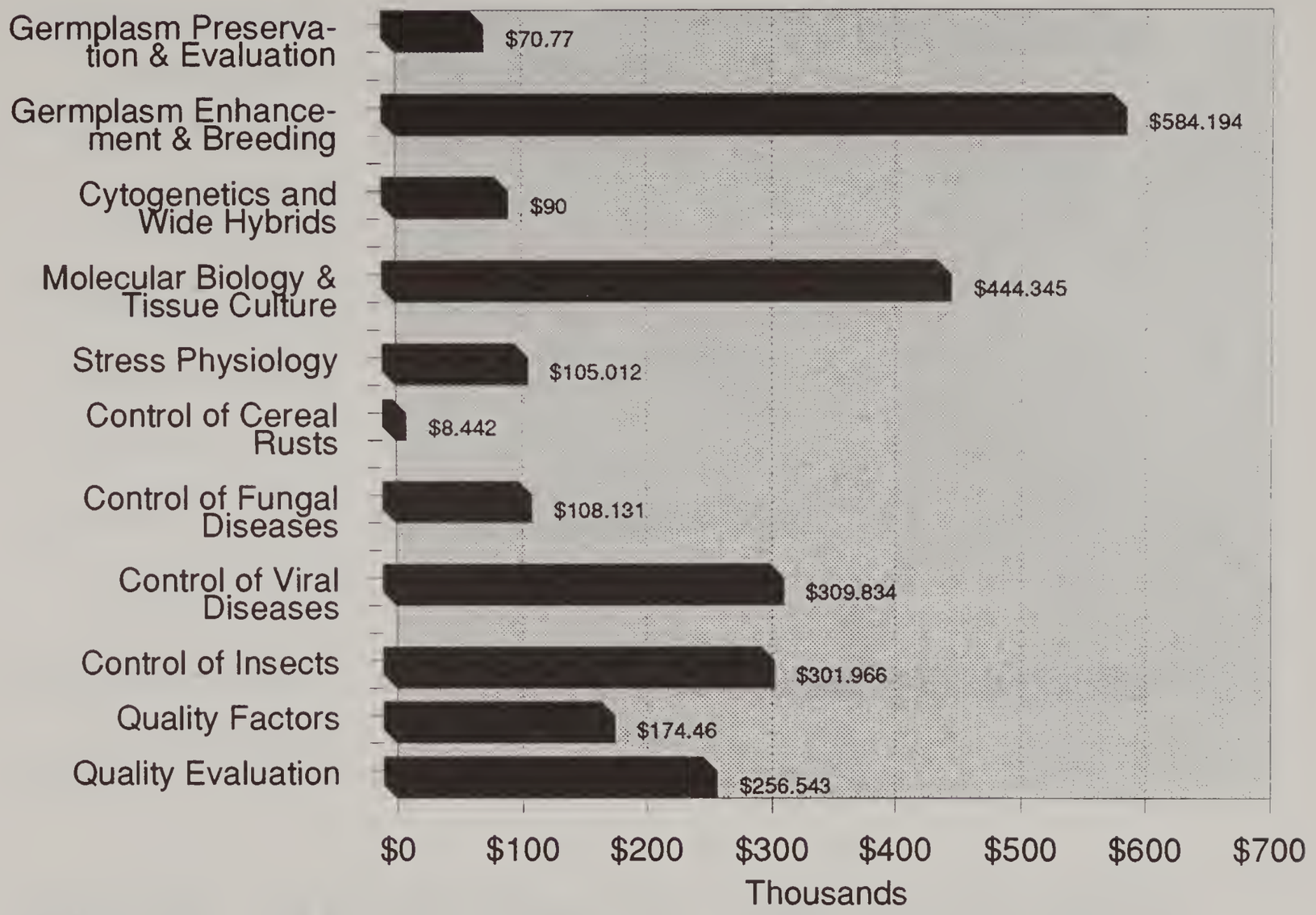


Grain Crops Review, May 6-10, 1991

OATS RESEARCH ($1,871,026)

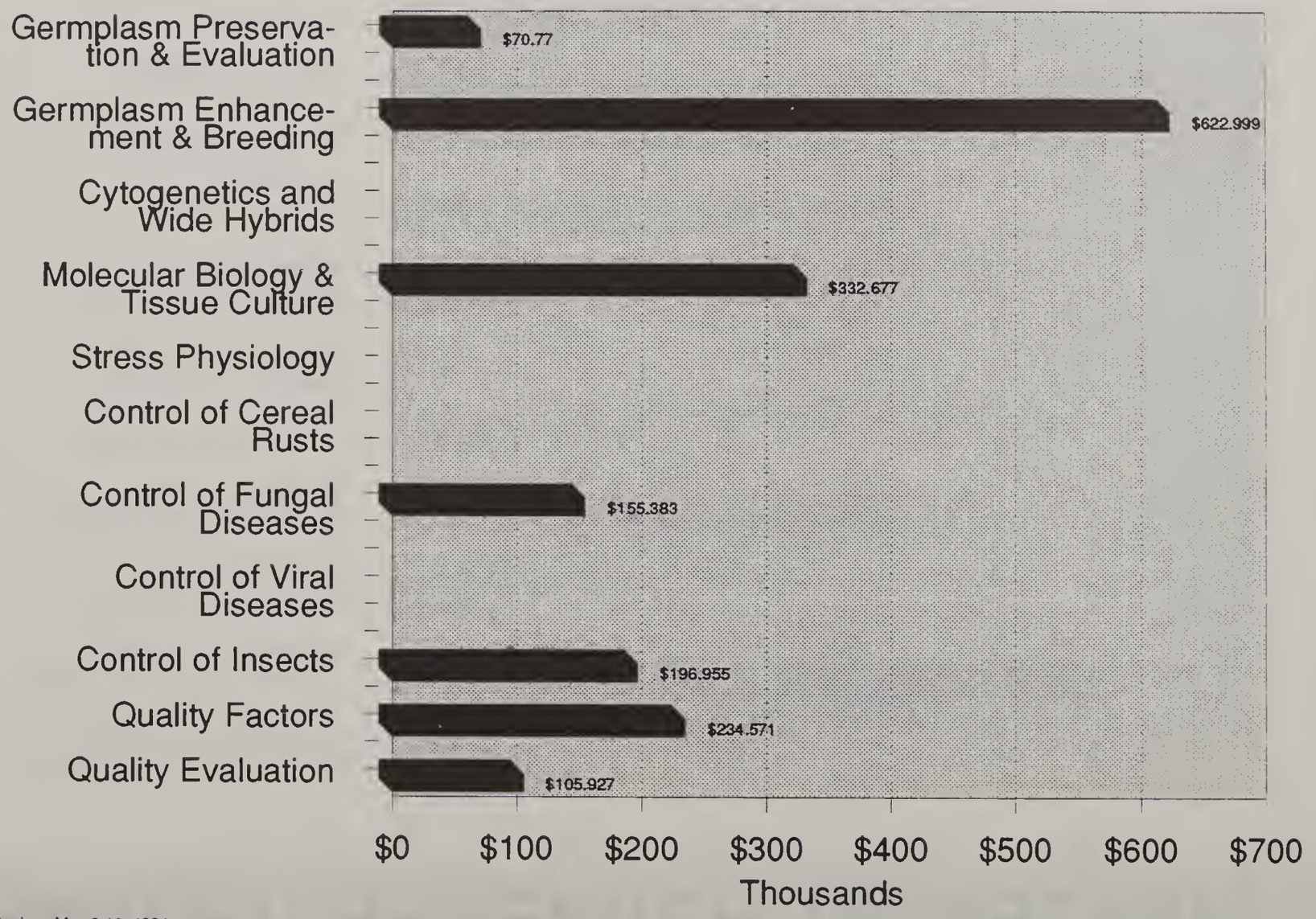


BARLEY RESEARCH ($2,453,697)

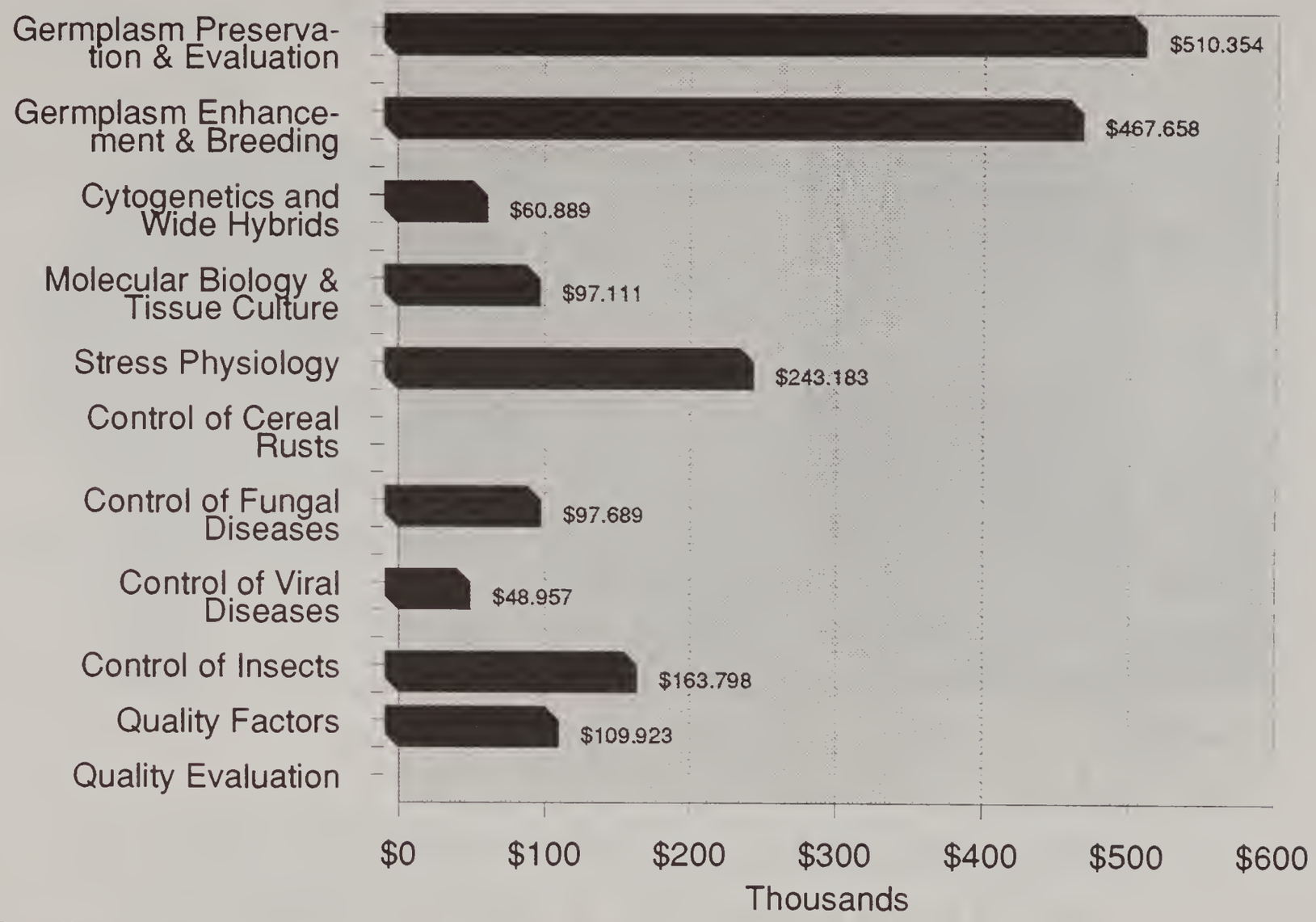


Grain Crops Review, May 6-10, 1991

RICE RESEARCH ($1,719,282)

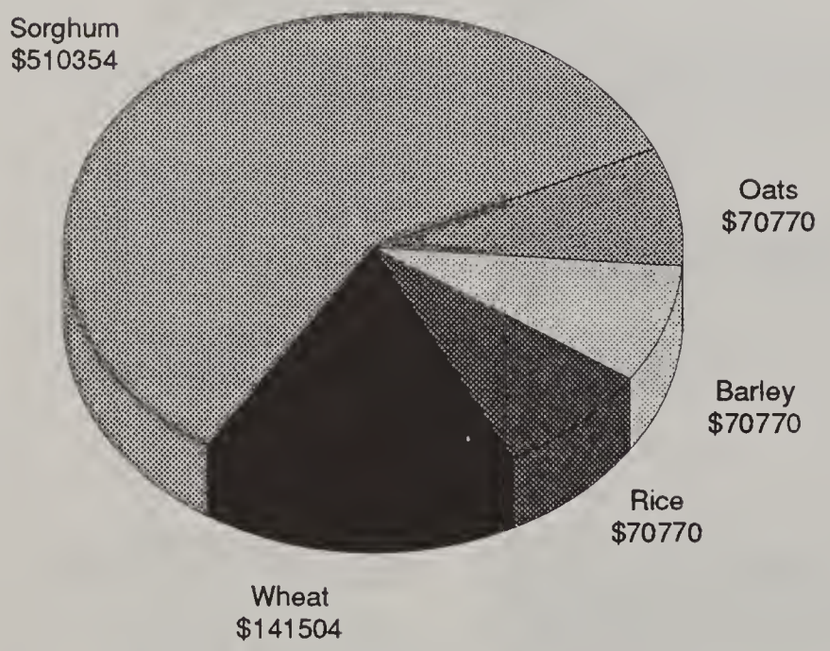


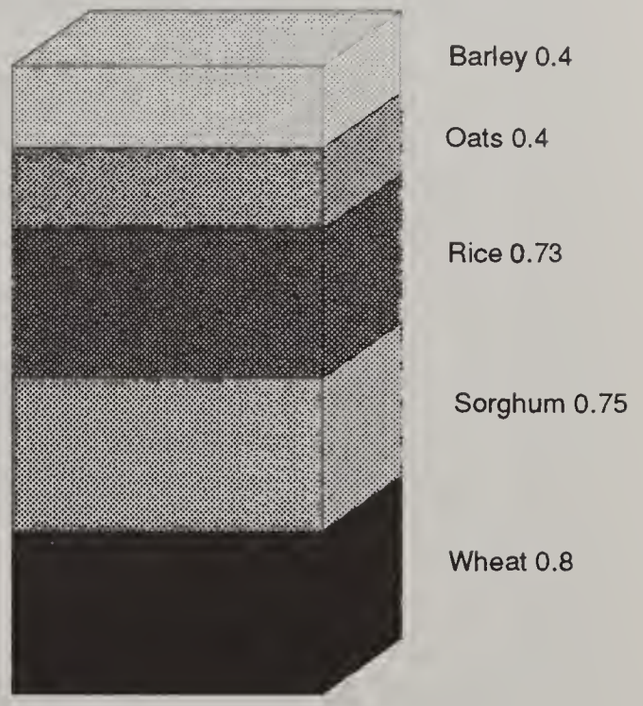
SORGHUM RESEARCH ($1,799,562)



Grain Crops Review, May 6-10, 1991

GERMPLASM PRESERVATION EVALUATION AND QUARANTINE



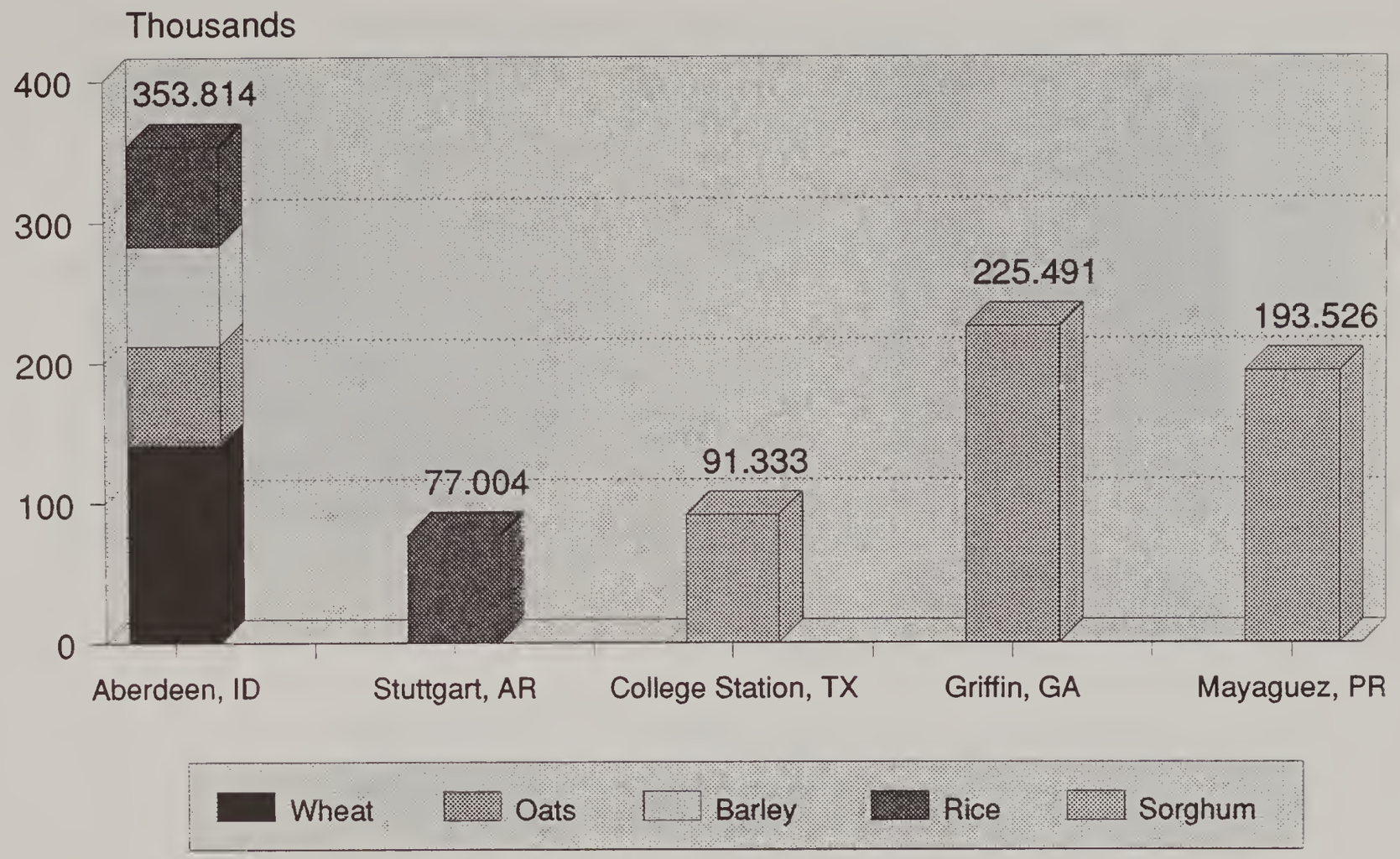


FUNDING - $864,164

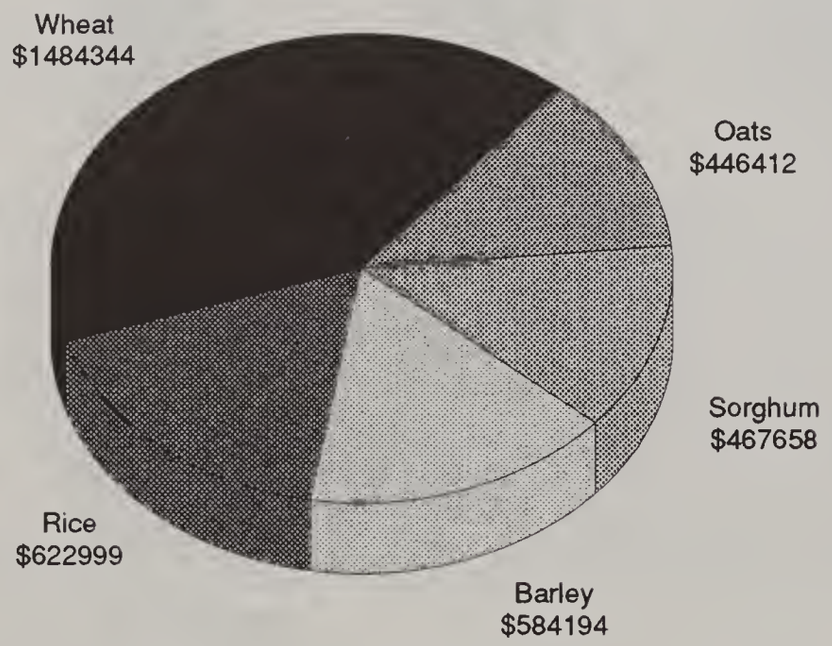
SY's - 3.08

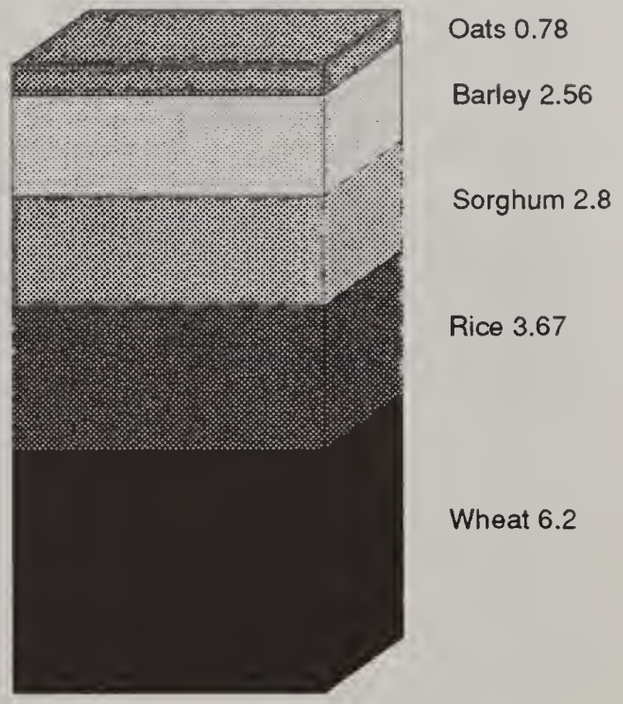
GERMPLASM PRESERVATION, EVALUATION AND QUARANTINE

Funding at Location



GERMPLASM ENHANCEMENT AND BREEDING



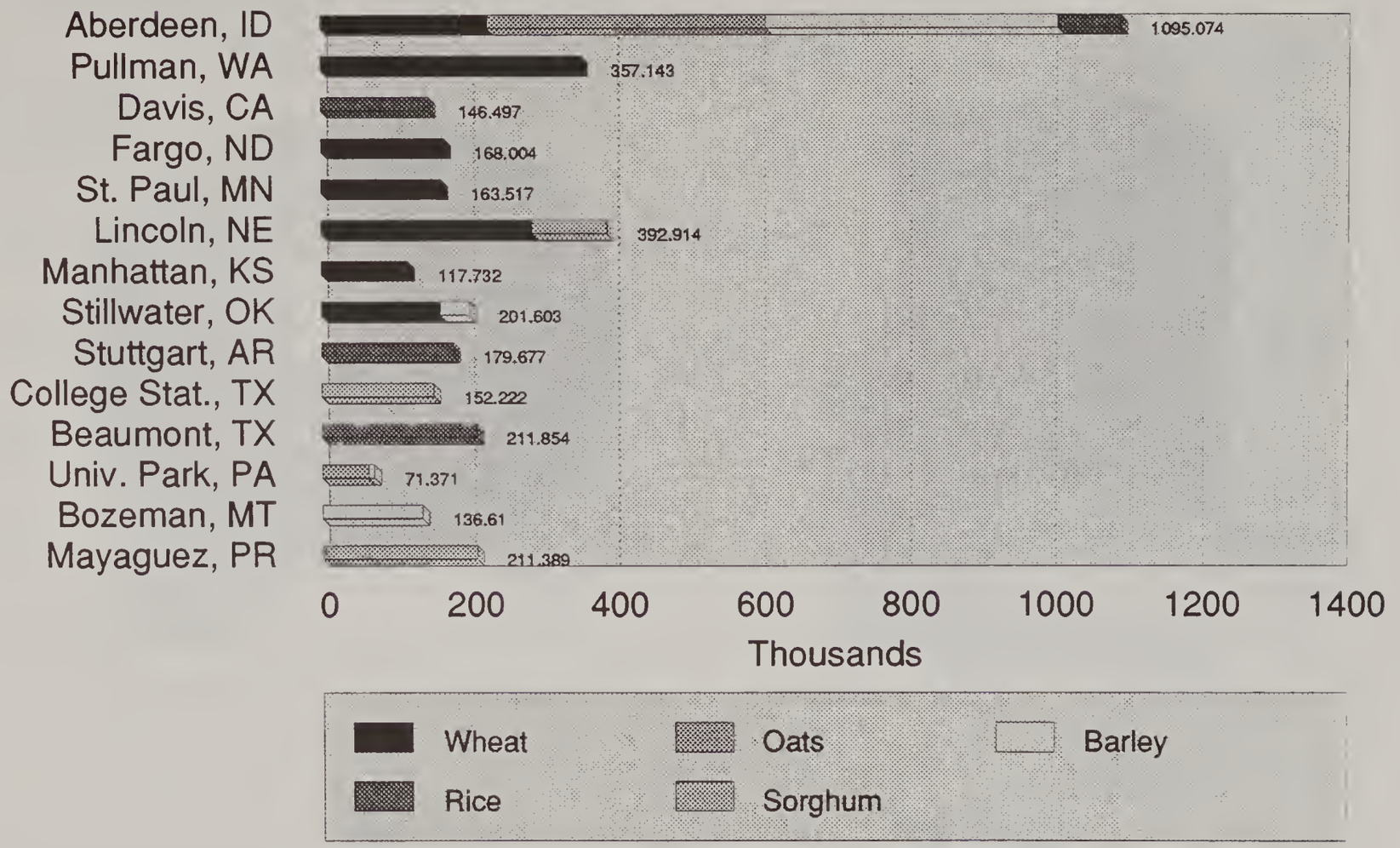


FUNDING - $3,605,607

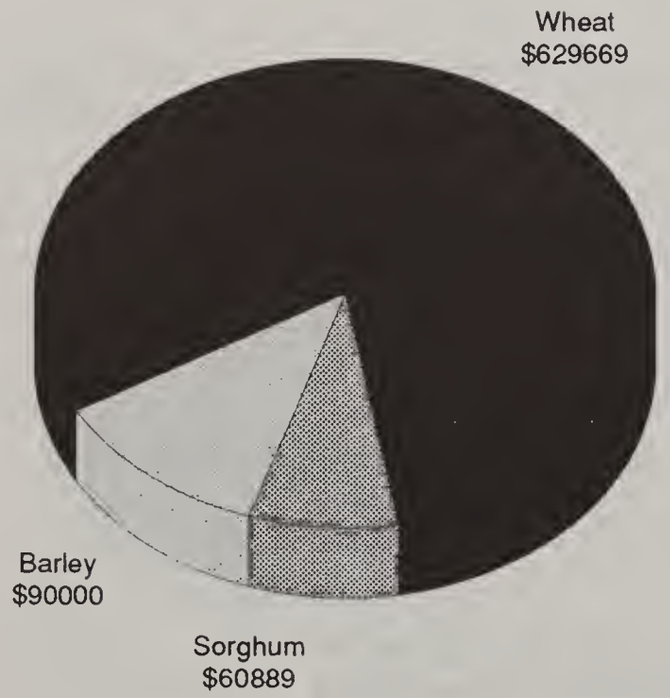
SY's - 16.01

GERMPLASM ENHANCEMENT AND BREEDING

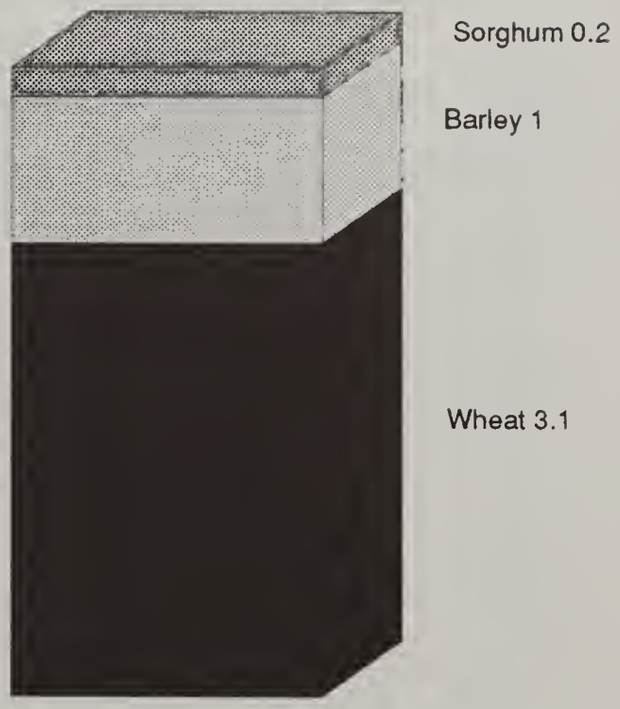
Funding at Location



CYTOGENETICS AND WIDE HYBRIDS

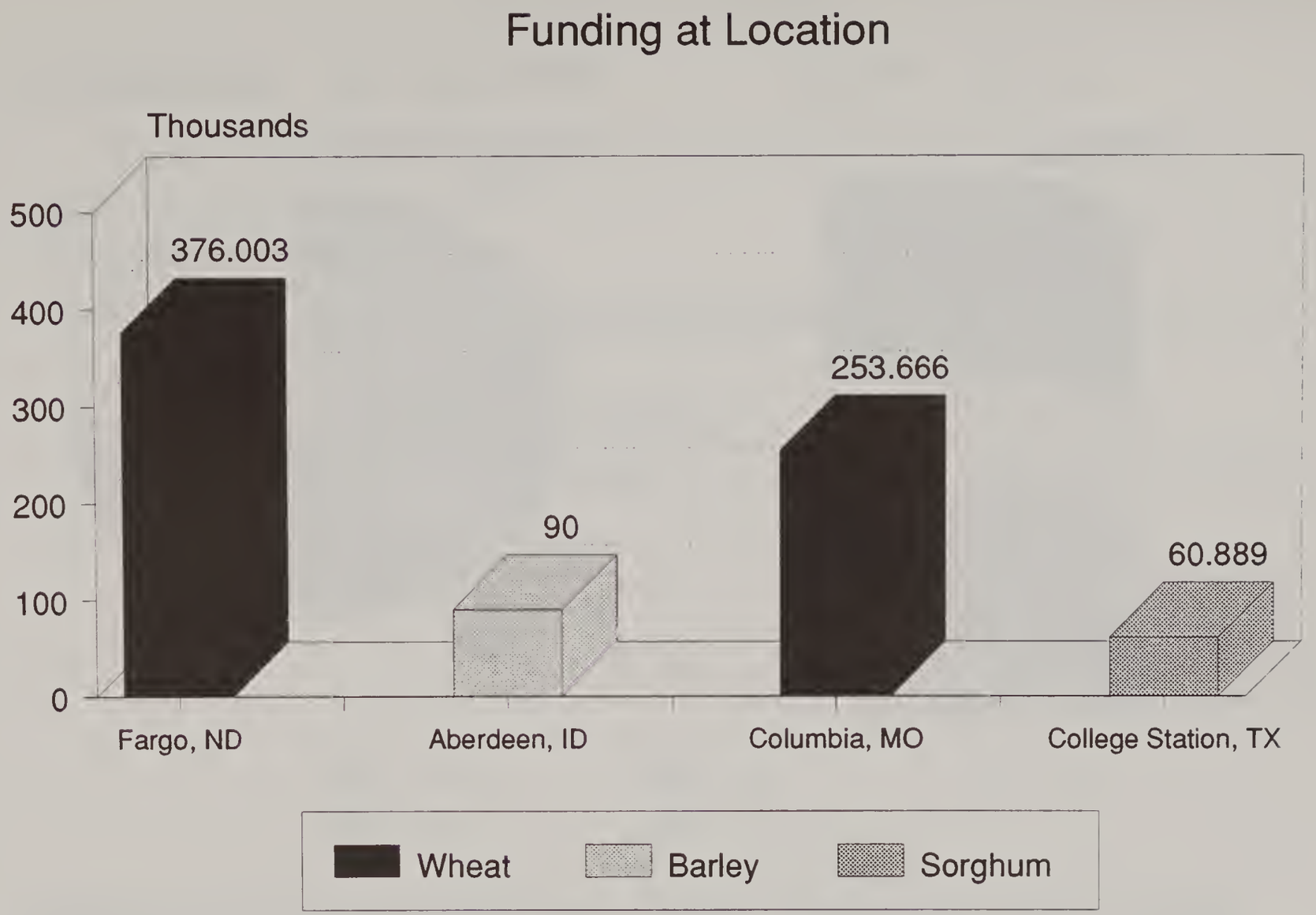


FUNDING - $780,558



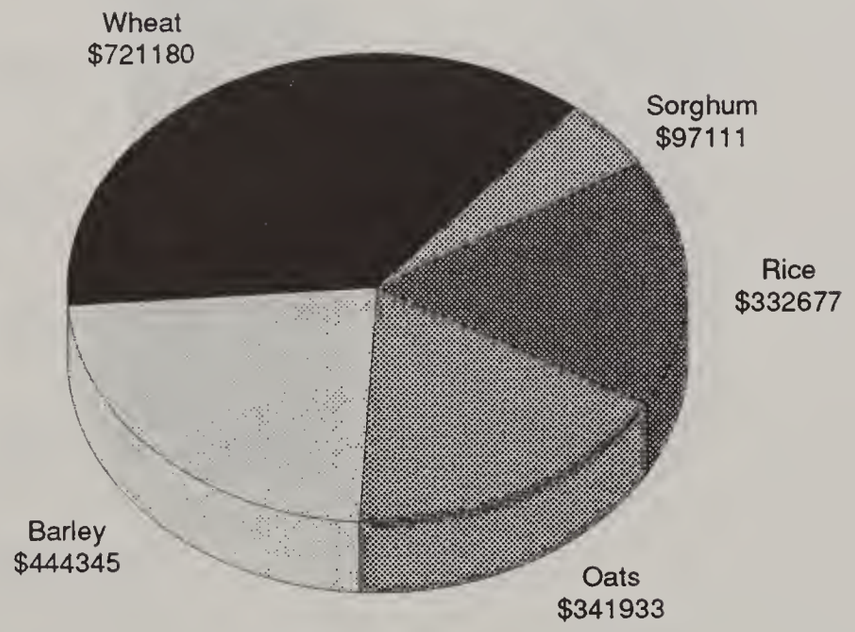
SY's - 4.3

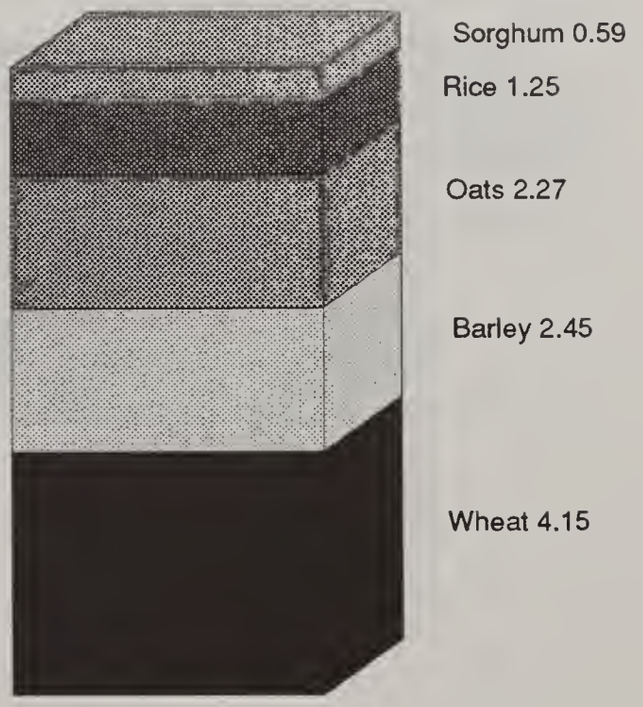
CYTOGENETICS AND WIDE HYBRIDS



Grain Crops Review-May 6-10, 1991

MOLECULAR BIOLOGY AND TISSUE CULTURE



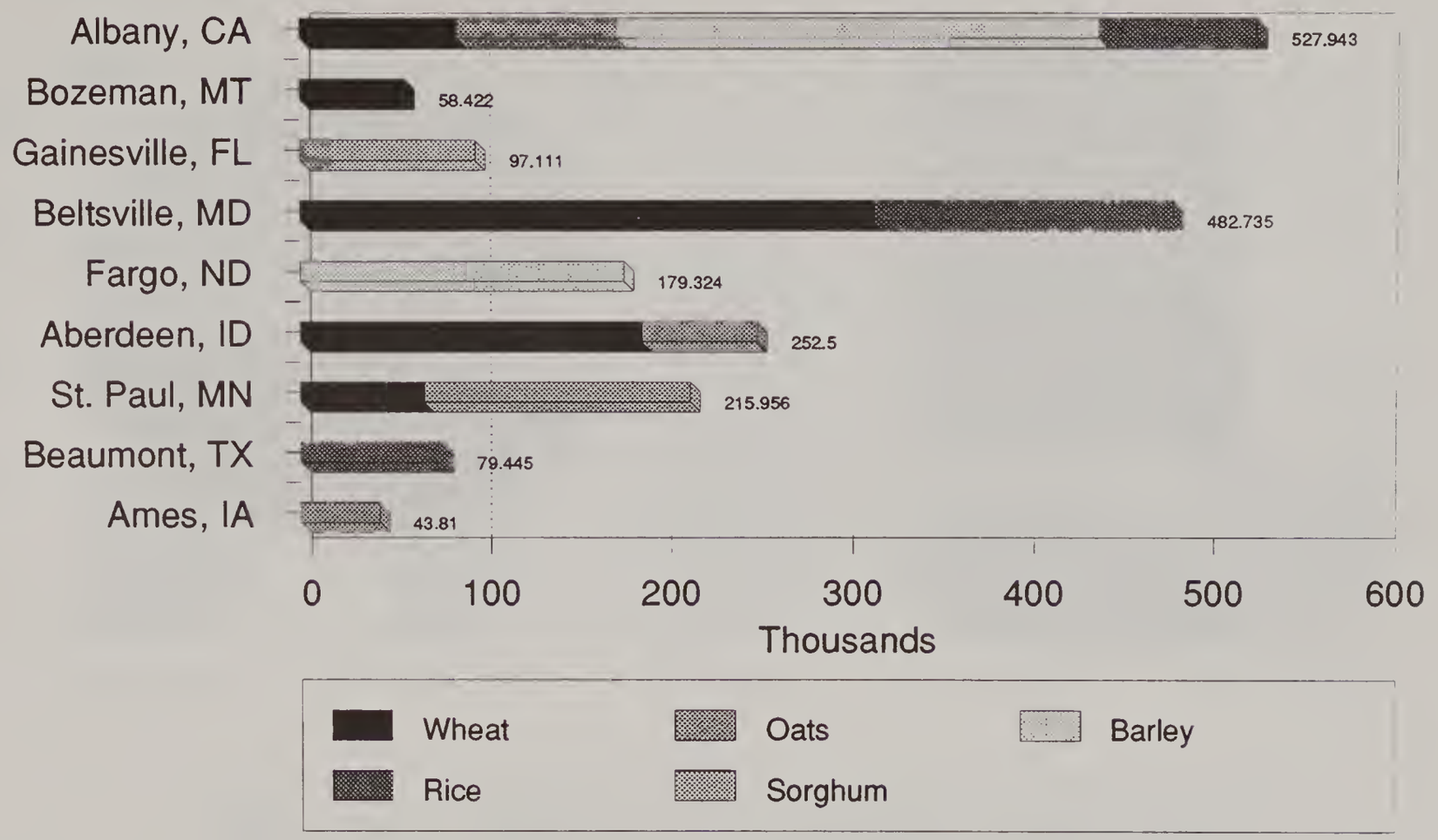


FUNDING - $1,937,246

SY's - 10.71

MOLECULAR BIOLOGY AND TISSUE CULTURE

Funding at Location



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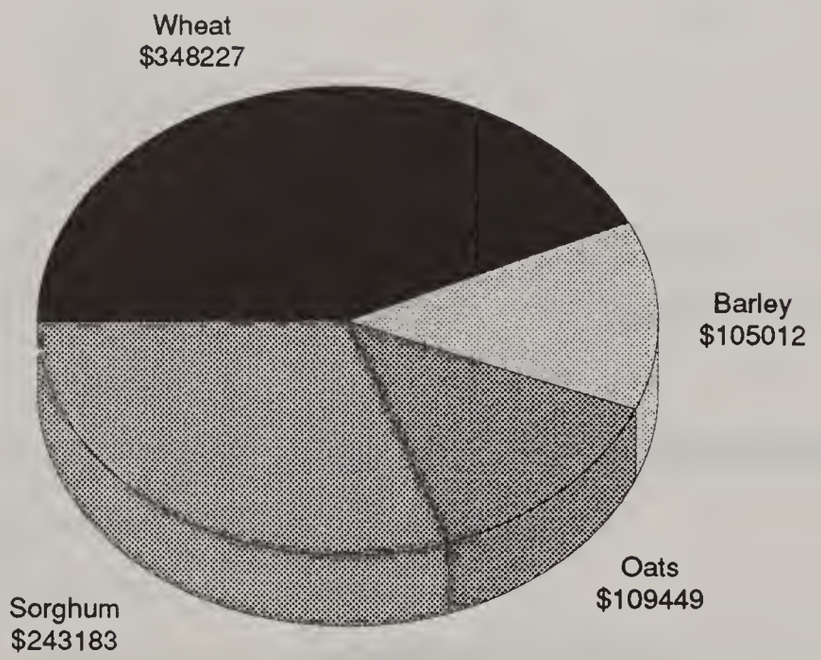
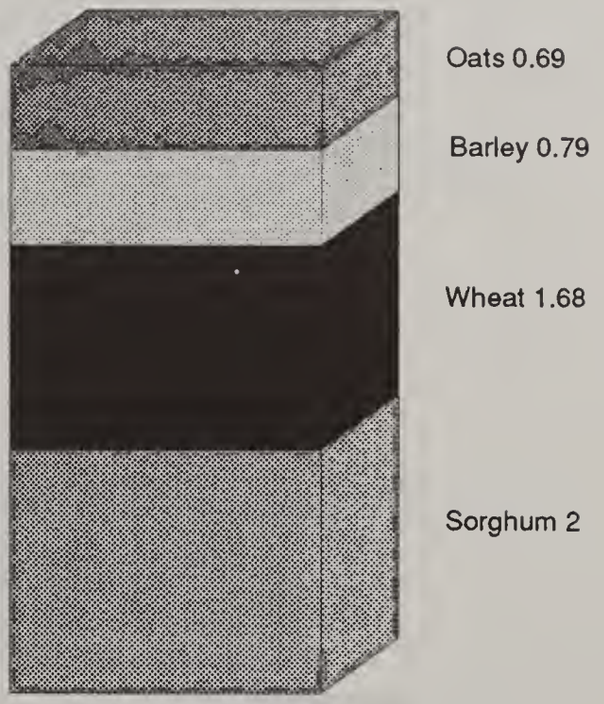
STRESS PHYSIOLOGY

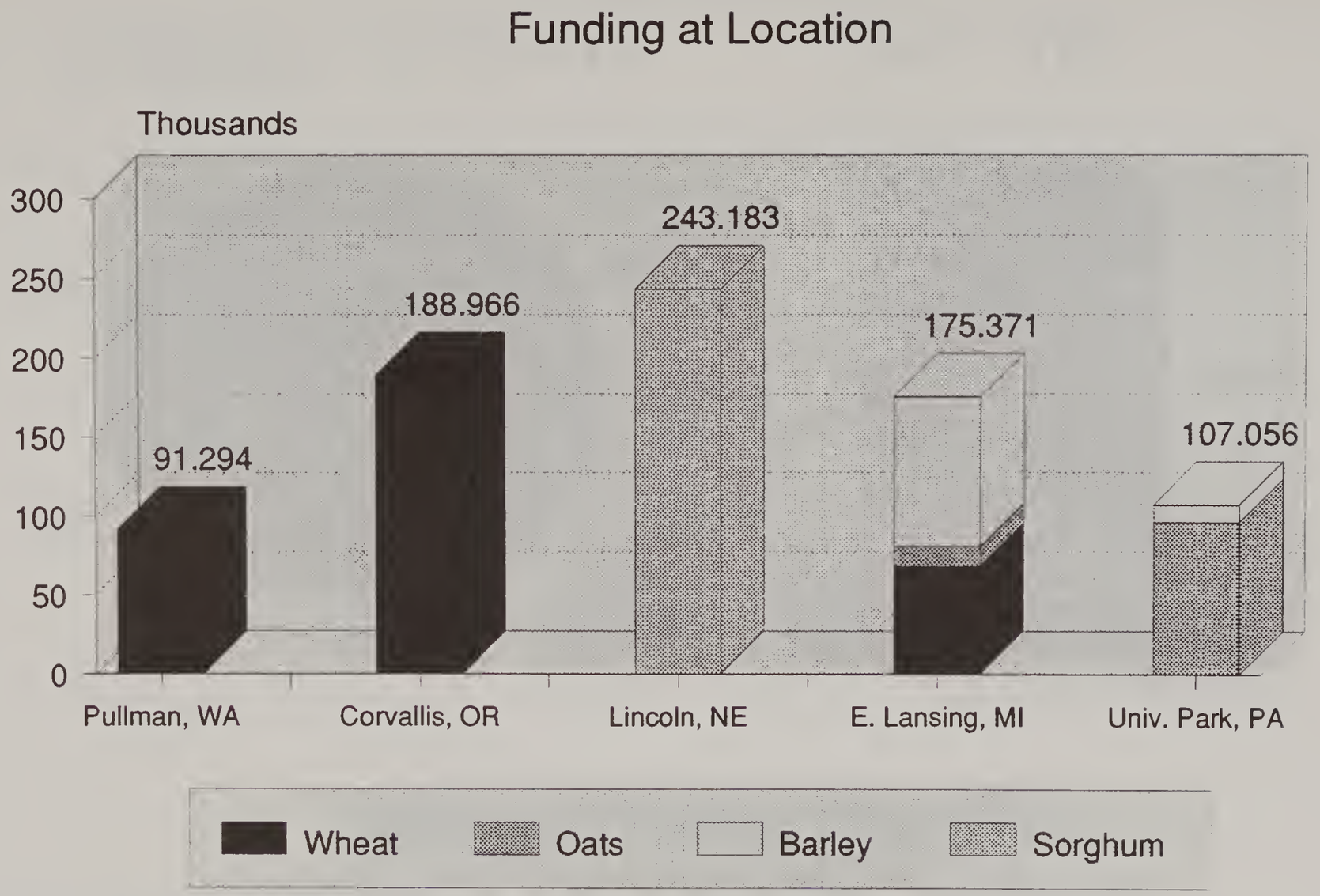




FUNDING - $805,871

SY's - 5.16

STRESS PHYSIOLOGY



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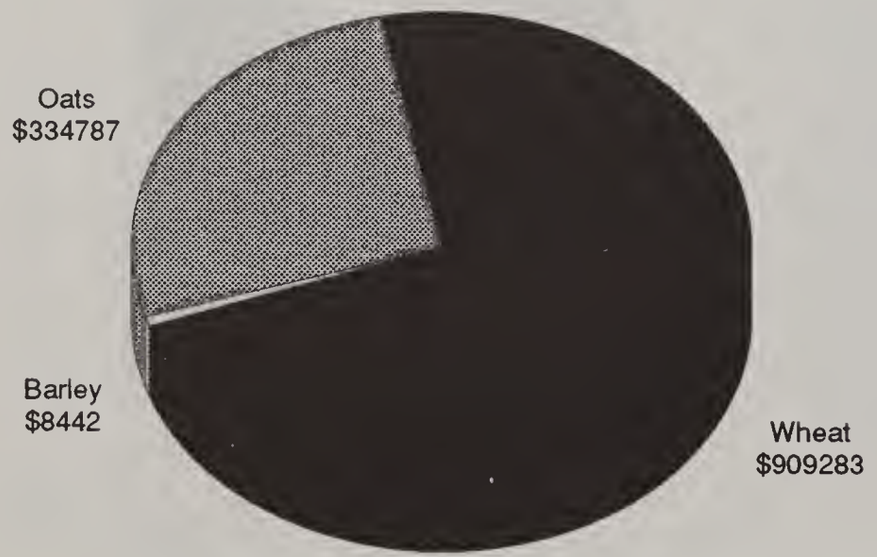
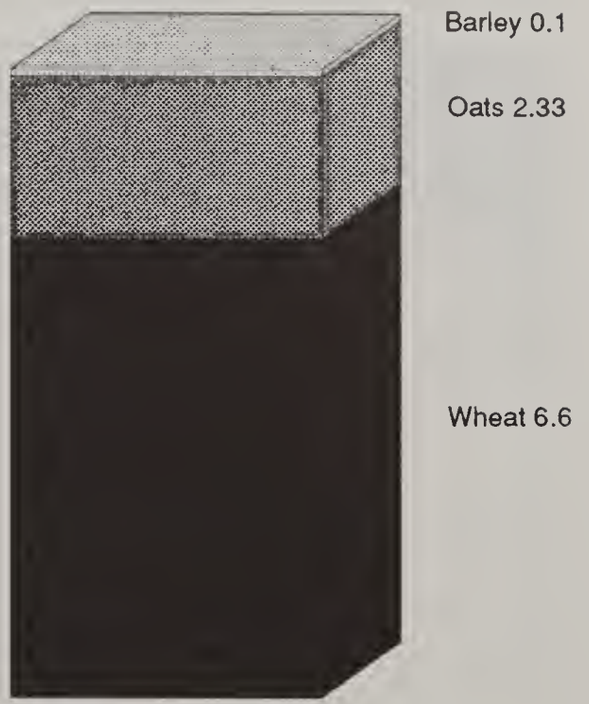
CONTROL OF CEREAL RUSTS

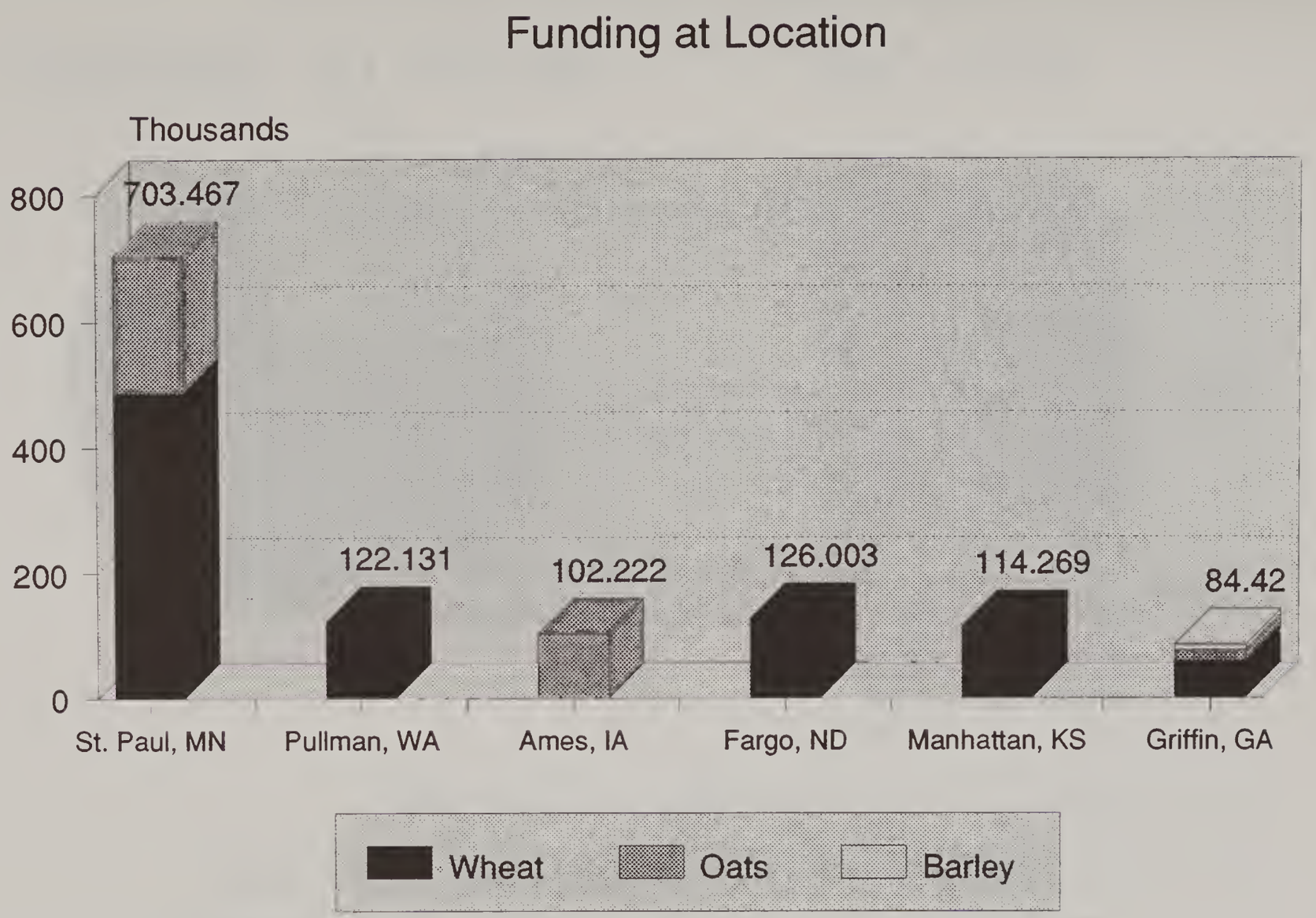




FUNDING - $1,252,513

SY's - 9.03

CONTROL OF CEREAL RUSTS



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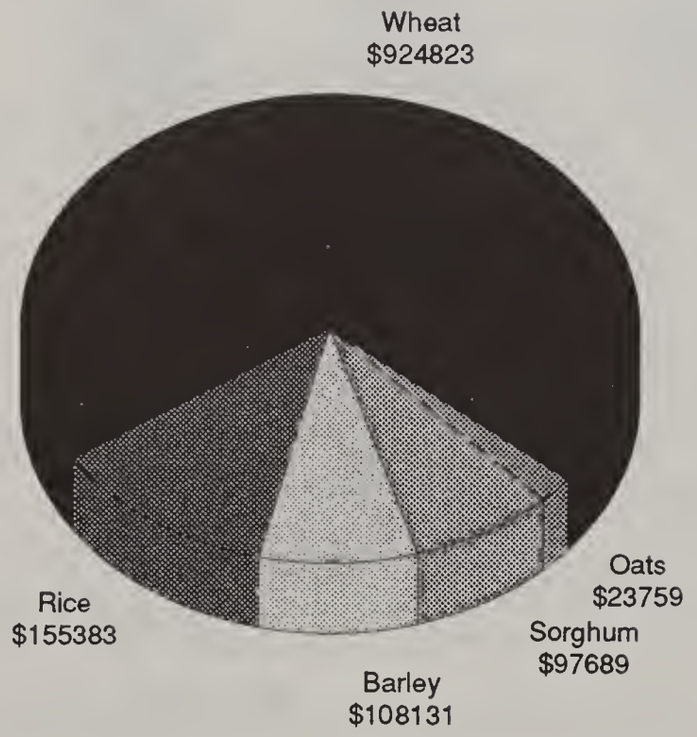
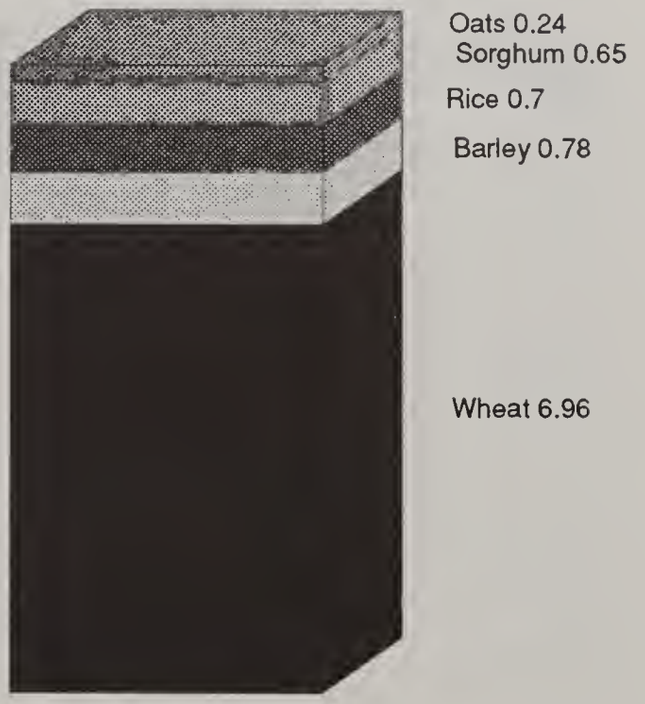
CONTROL OF OTHER FUNGAL AND BACTERIAL DISEASES



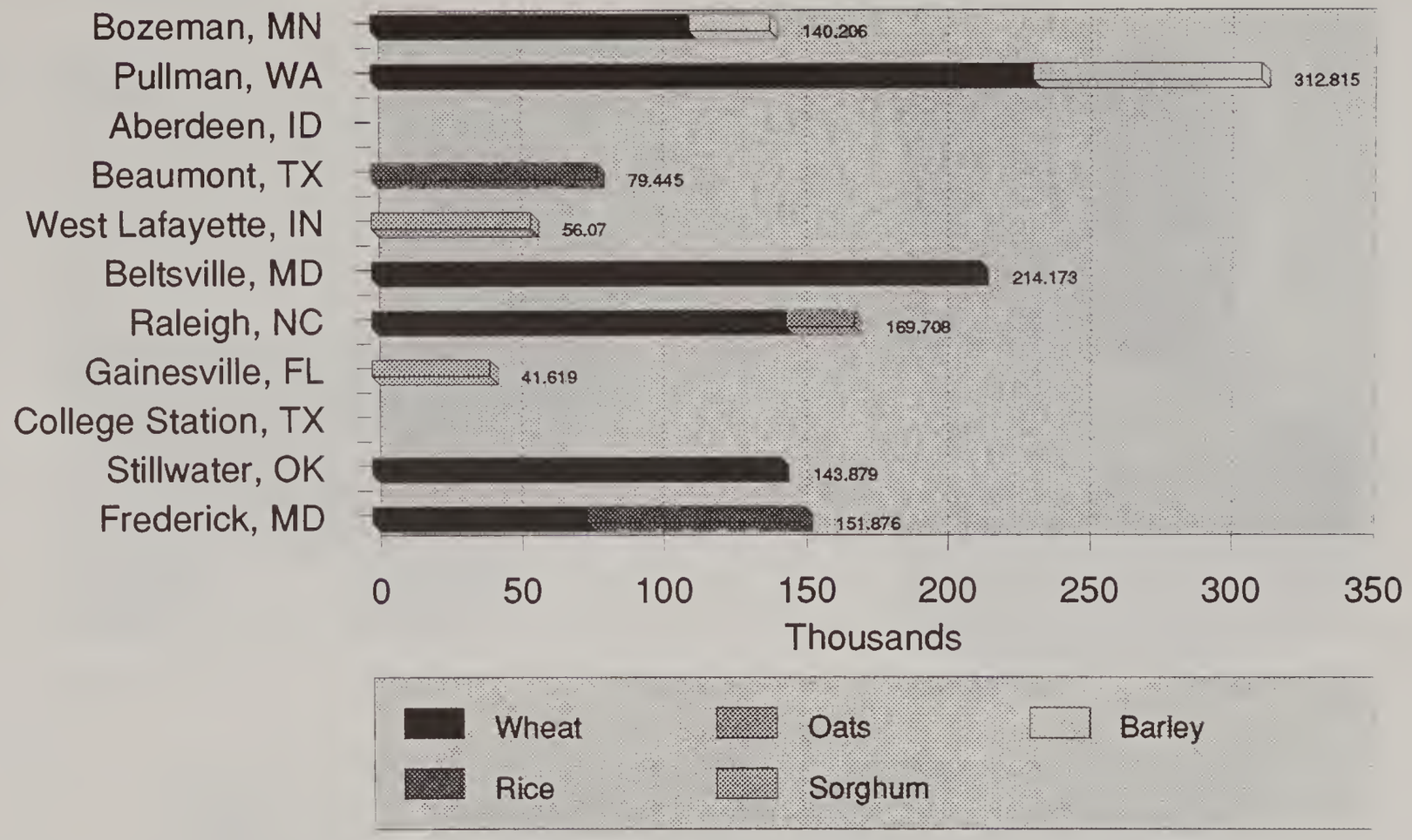
FUNDING - $1,309,785



SY's - 9.33

CONTROL OF OTHER FUNGAL AND BACTERIAL DISEASES

Funding at Location



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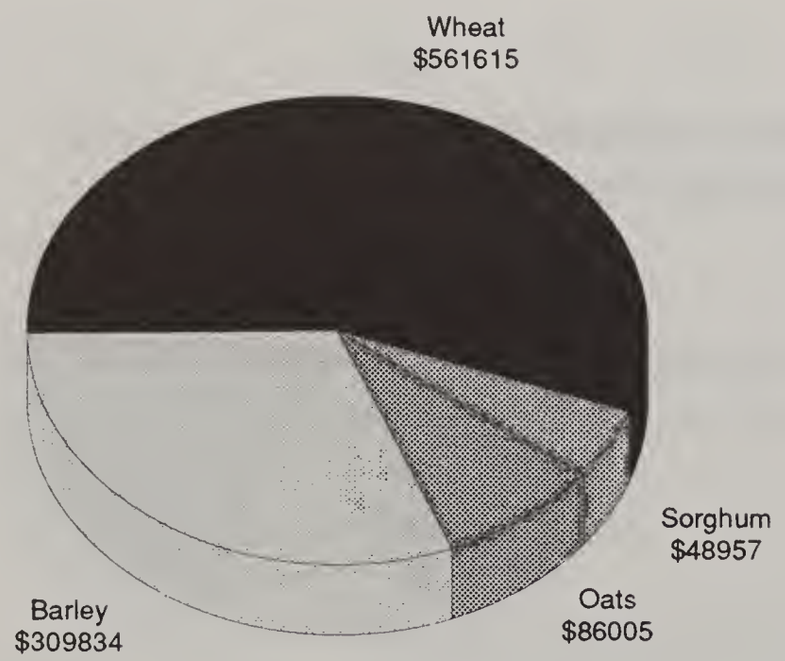
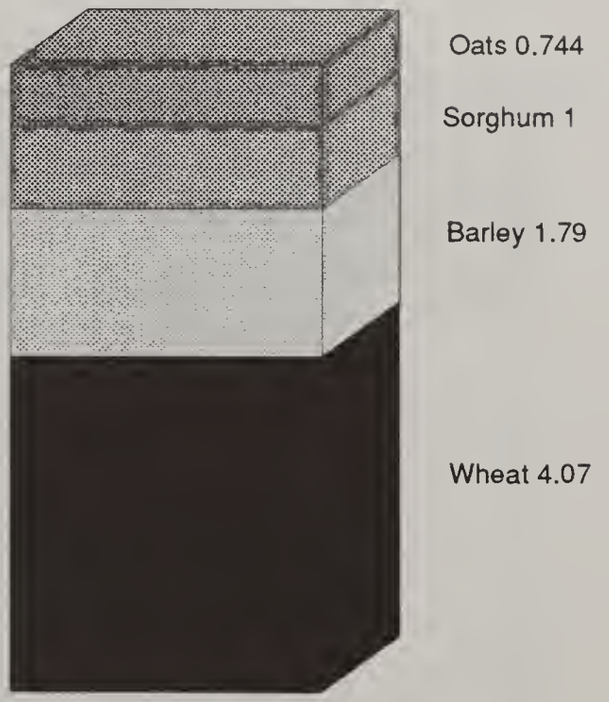
CONTROL OF VIRAL DISEASES

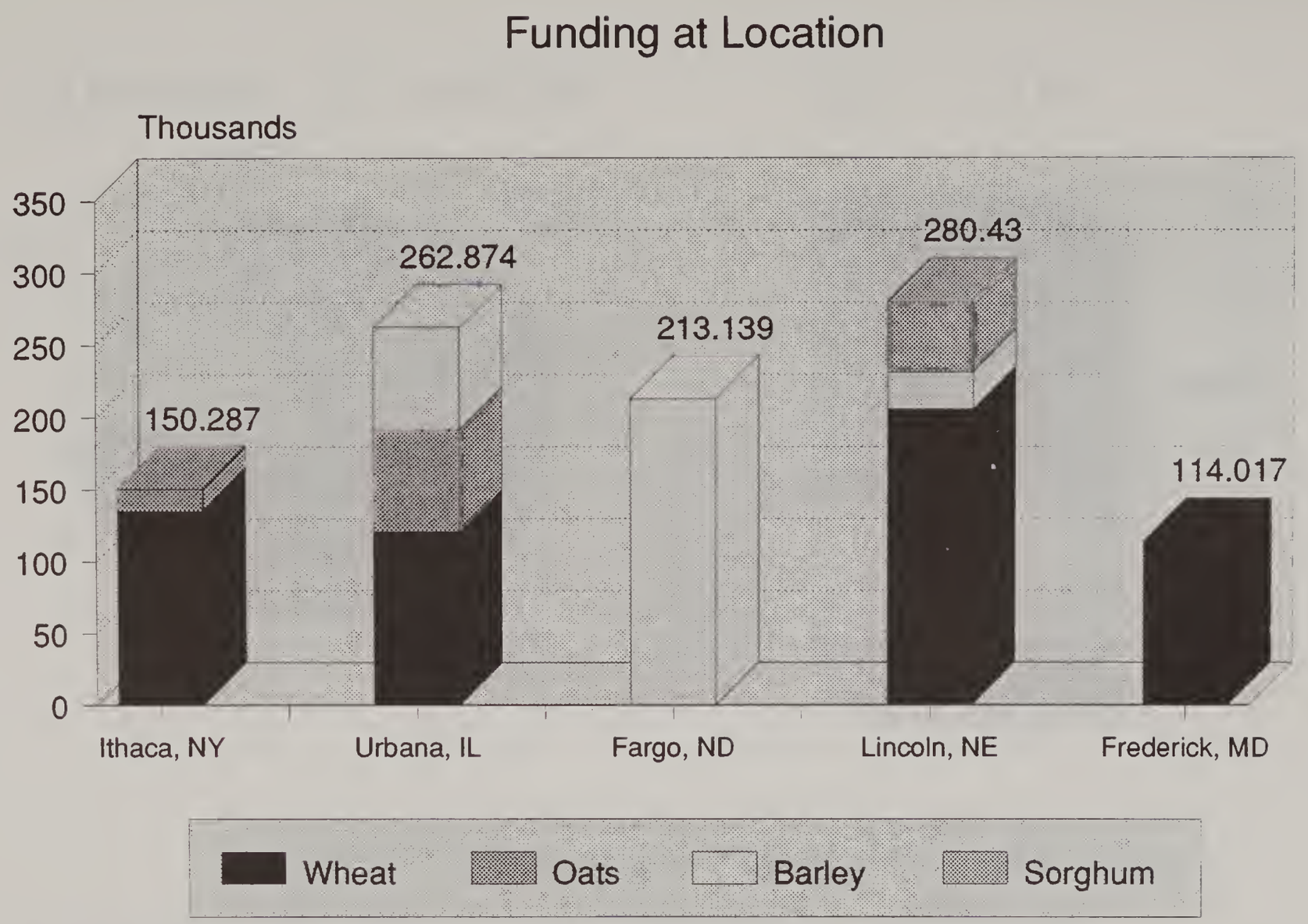




FUNDING - $1,006,411

SY's - 7.6

CONTROL OF VIRAL DISEASES



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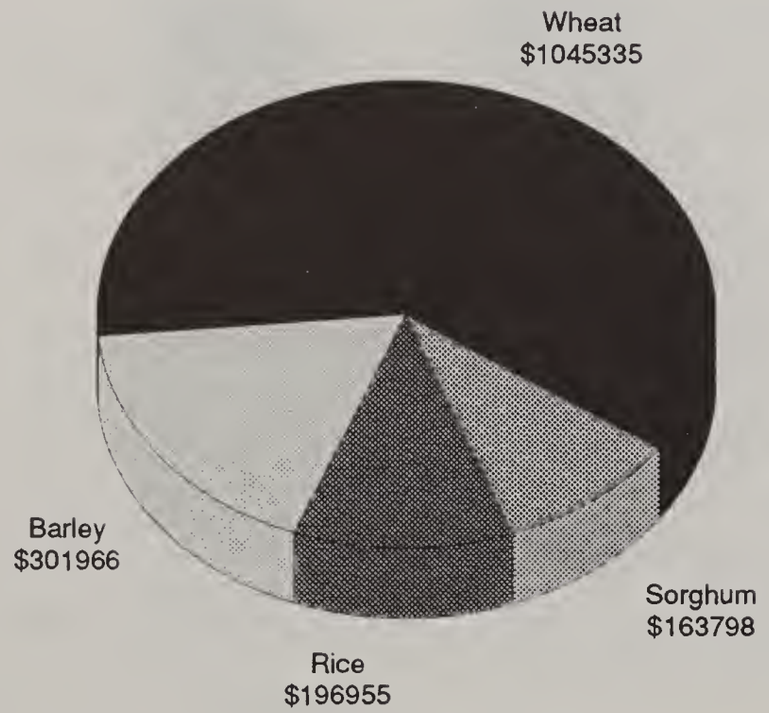
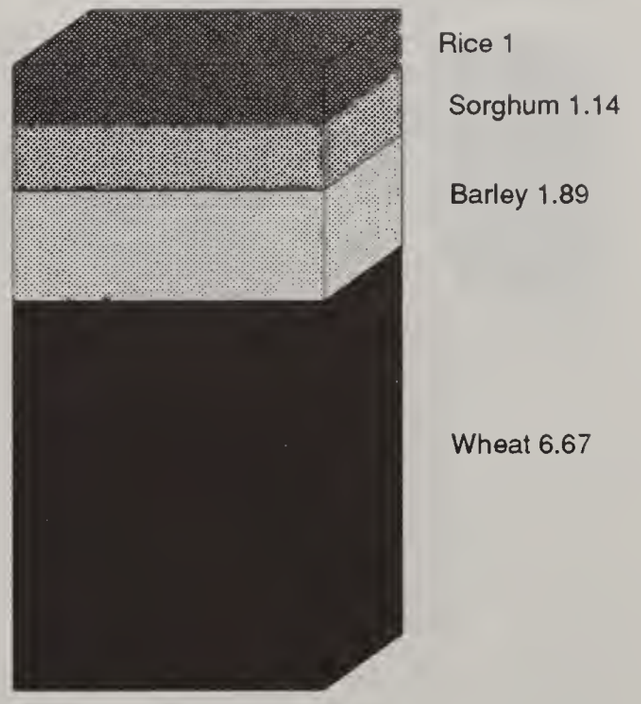
CONTROL OF INSECT PESTS

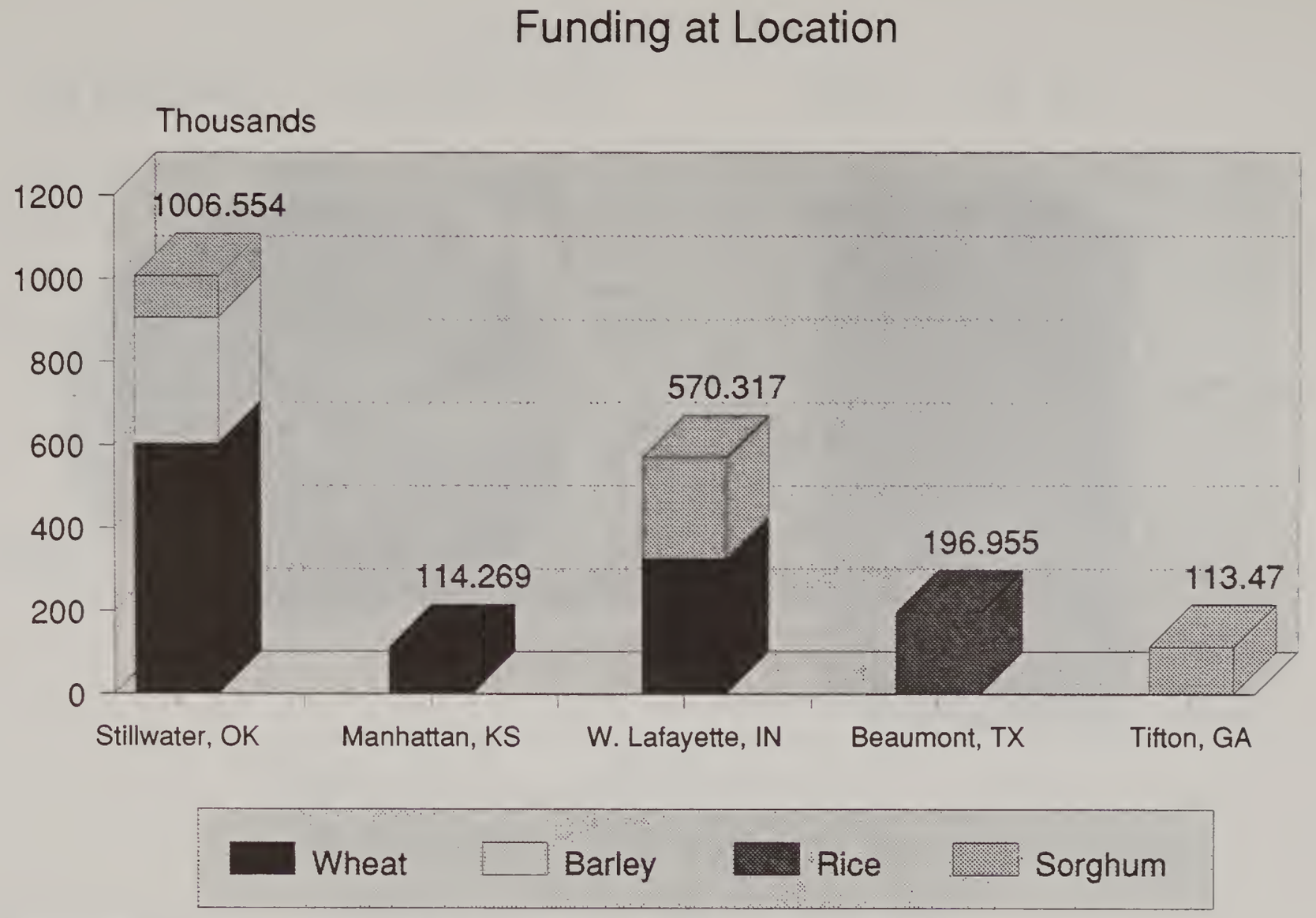


FUNDING - $1,708,054



SY's - 10.8

CONTROL OF INSECT PESTS



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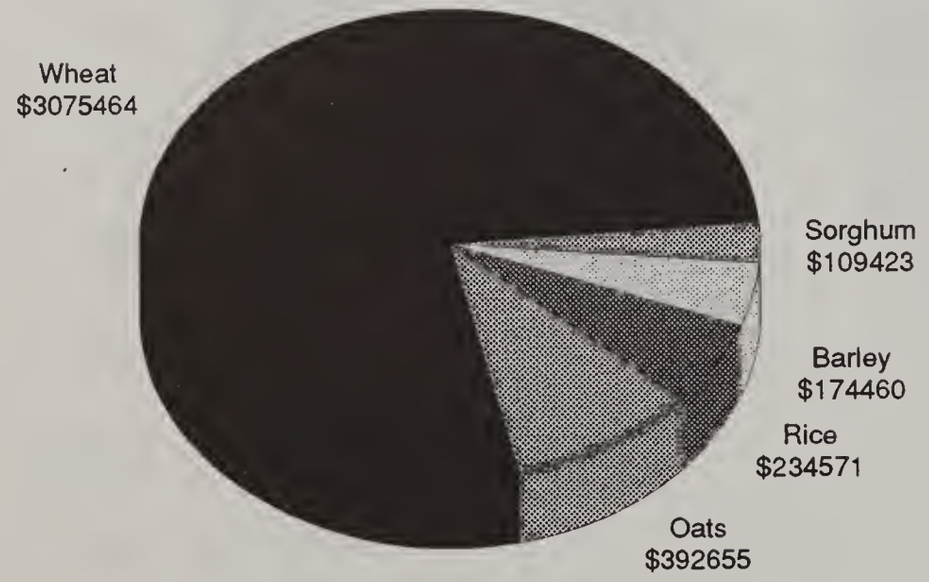
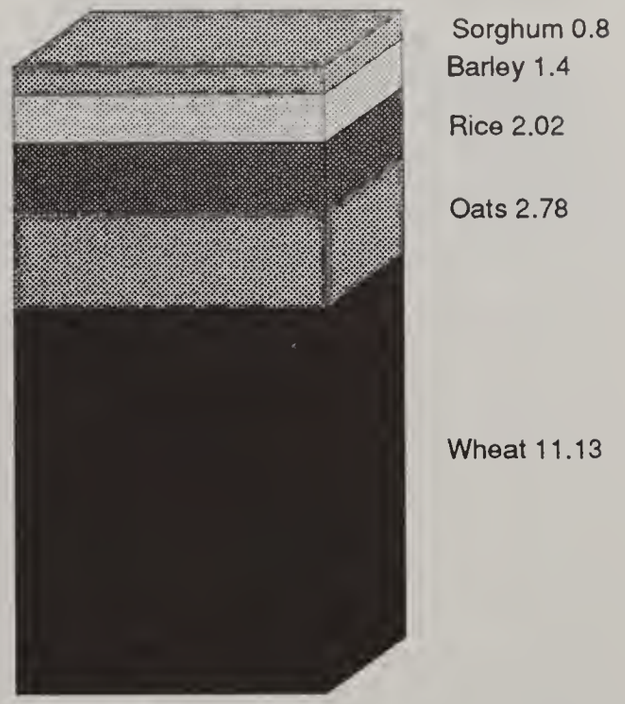
QUALITY FACTORS



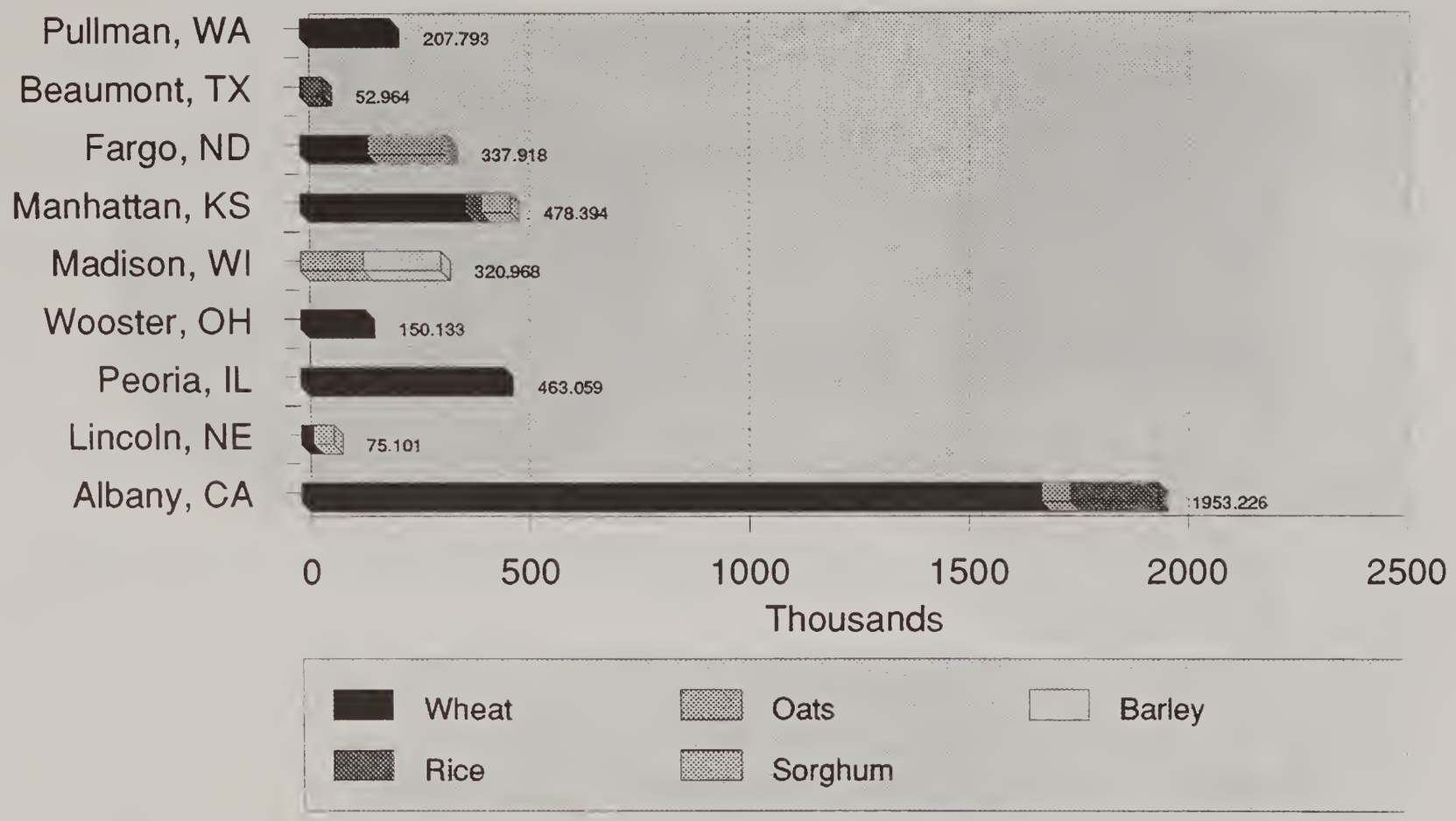


FUNDING - $3,986,573

SY's - 18.13

QUALITY FACTORS

Funding at Location



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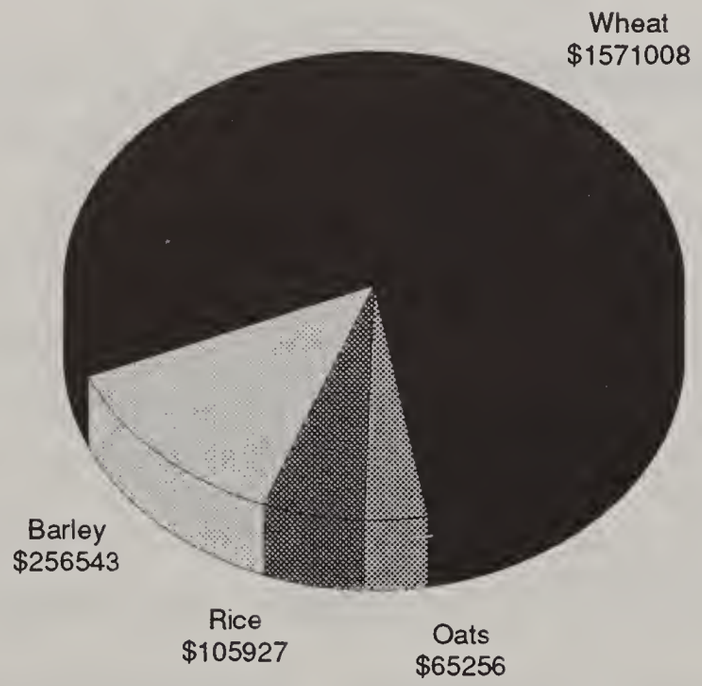
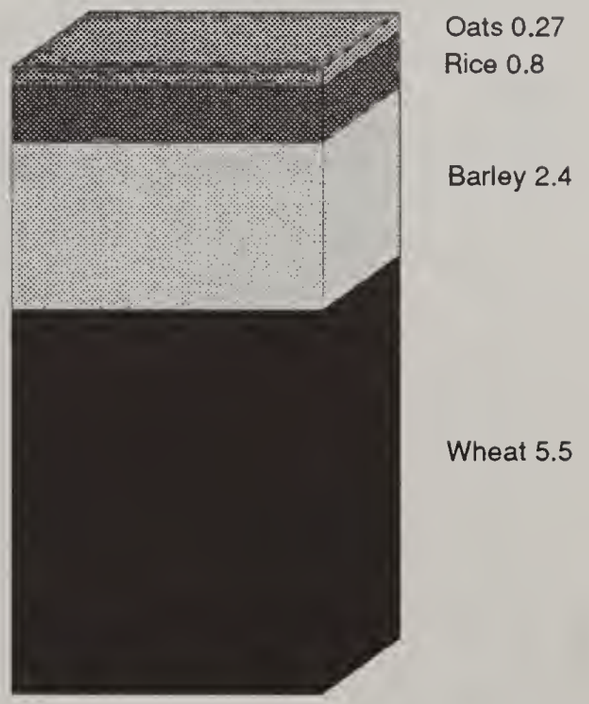
QUALITY EVALUATION

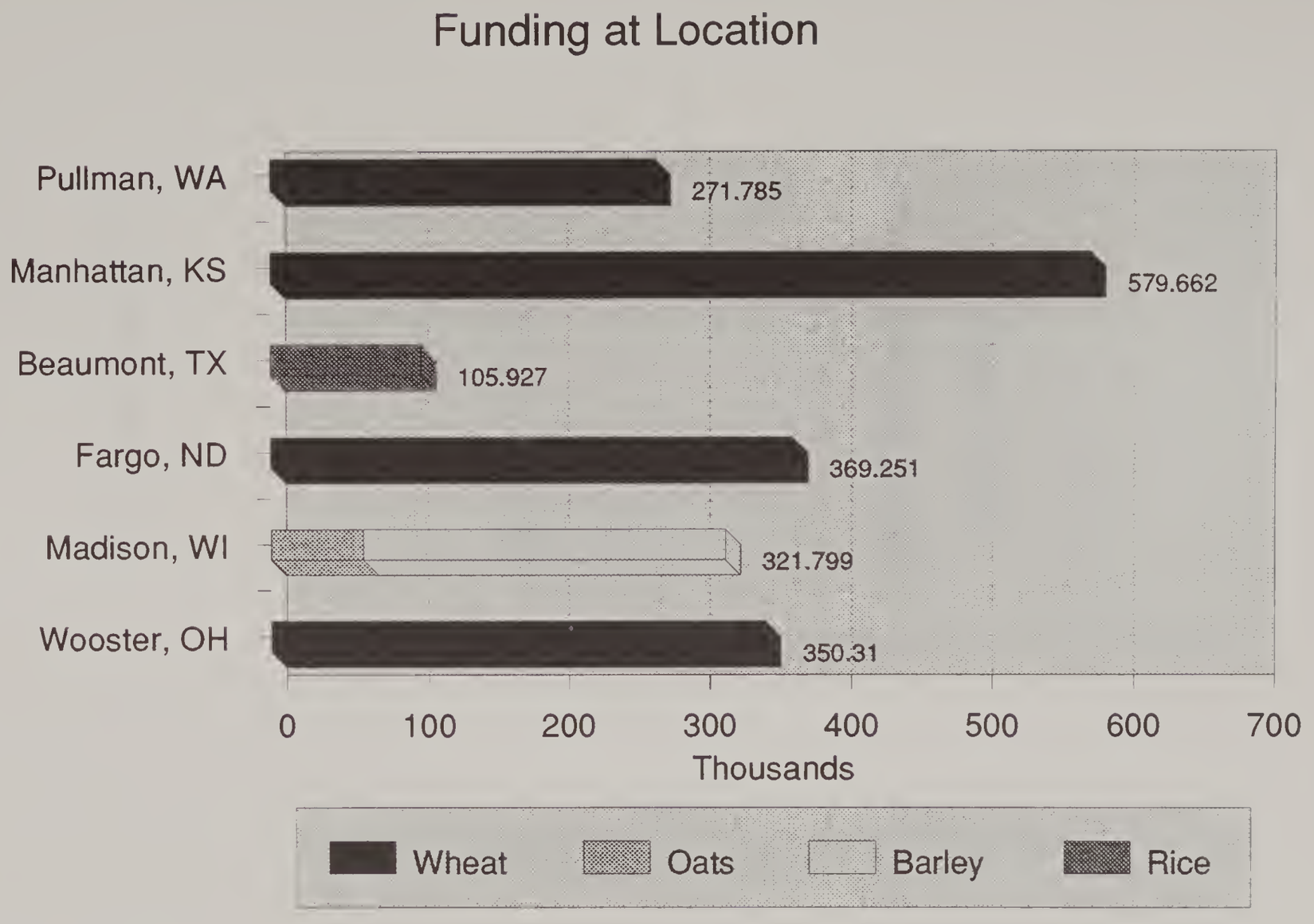




FUNDING - $1,998,734

SY's - 8.57

QUALITY EVALUATION



Grain Crops Review-May 6-10, 1991

Appendix B

ARS GRAIN CROP PRODUCTION AND QUALITY REVIEW

ST. LOUIS, MISSOURI

MAY 6-10, 1991

LOCATION SUMMARIES

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Wheat

Project Scientist: Robert Busch

Management Unit Representative: Howard Rines

Management Unit: Plant Science Research Unit

Location: St. Paul, Minnesota

Objectives/Approach:

The objectives of the wheat genetics project at St. Paul are to determine genetic control of agronomic and quality traits of wheat, evaluate accessions of wheat in the National Small Grains Collection for disease resistance and other traits, and develop improved hard red spring wheat germplasm for public release. Approaches include: 1) Two long term recurrent selection programs, one for kernel weight and one for grain protein; 2) Determination of alien cytoplasm effects on rust resistances and other traits in modern semidwarfs; 3) Development and evaluation of rye substitution lines in spring wheat; 4) Comparisons of doubled haploid progeny populations, one derived by anther culture and one derived by wheat X maize hybridizations, to a population derived by single seed descent; 5) Evaluation of wheat accessions for rust resistances and other traits for entry into GRIN; and 6) Development and release of hard spring wheat germplasm and cultivars and coordination of the Regional Uniform Hard Red Spring Wheat Nursery.

Status of Research:

The cultivar Marshall developed by this project remains the dominant spring wheat grown in Minnesota. Minnpro, a very high protein cultivar, and Vance were released in 1989 and are still in seed increase. Four cycles of recurrent selection for grain protein were effective, resulting in an increase of 0.5 percentage points per cycle; however, yield may have been reduced. Rye chromosome subsitution lines of 1 R for 1 D of wheat in Marshall and Wheaton are being evaluated over multiple locations and years. An anther culture derived, doubled haploid population of a spring wheat cross performed similar to a single seed descent population from the same cross in 1989, but had a significantly lower mean yield in 1988, a year with much drought stress. Several thousand hard red spring and durum wheat accessions from the National Small Grains Collection have been evaluated for stem rust resistance, but most winter wheat accessions were winter-killed when they were grown for evaluation in 1990.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Barley
Management Unit Representative: Norman D. Williams
Management Unit: Cereal Crops Research
Location: Fargo, North Dakota

Objectives/Approach:
The mission of the Cereal Crops Research Unit at Fargo is to provide basic knowledge and improved germplasm for developing, maintaining, and improving hard red spring wheat, durum, barley, and oat. Major barley objectives are: 1) To increase knowledge of barley-virus interactions and facilitate development of effective control measures for virus diseases, with emphasis on barley stripe mosaic virus (BSMV), oat blue dwarf virus (OBDV), and barley yellow dwarf virus (BYDV). BSMV research involves the study of virus genetics and mechanisms of pathogenesis through construction and analysis of viral cDNA clones by sequencing, recombination, and mutation techniques; evaluation and characterization of strains; and the study of resistance mechanisms using protoplasts. OBDV research involves improvement of purification procedures, characterization of the virus and its components, development of a protoplast system, and eventually genetic analyses similar to those for BSMV. BYDV research is on alternative sources of resistance or tolerance and evaluation of cultivars for response to infection. 2) To improve barley quality and production efficiency through application of procedures such as tissue culture, anther culture, recombinant DNA techniques and genetic transformation, in vitro selection, and conventional genetic and cytogenetic techniques. Molecular genetic techniques and morphological marker stocks will be used to identify and map genes to chromosomes. Useful traits in barley cultivars, exotic lines, and related species will be identified and incorporated into enhanced germplasm lines. Restriction fragment length polymorphism (RFLP) analysis will be used for mapping the barley genome and for combining the molecular and morphological maps.

Status of Research:
Complete genomes of BSMV strains CV17 and CV42 were cloned, and the in vitro transcripts were infectious. The α and γ RNAs were important in determining both local and systemic pathogenicity, the γ RNA determined seed transmissibility in barley, and RNA α influenced symptom severity. The determinant for the ability of CV42 RNA α to suppress local lesion formation on Chenopodium amaranticolor was within the 3-prime terminal 1800 nucleotides of RNA α. The base sequence of the CV17 γ RNA was shown to be recombinant. Sequences of 15 RNA γ cDNA clones appeared to be identical. Direct sequencing of RNA purified from virions agreed with results of sequencing cDNA clones. Purification procedures for OBDV were developed, and approximate molecular weights of genomic RNA and coat protein were determined. Both malt quality and grain yield were affected by BYDV infection. Cooperation in eliminating BSMV from barley in the National Small Grains Collection and coordination of the Mississippi Uniform Regional Barley Nursery were continued. Hybrids of barley with Elymus canadensis created to transfer traits such as BYDV resistance, winter hardiness, and drought tolerance were sterile with little chromosome pairing; about 1,000 hybrid plants were regenerated from tissue cultures on media containing colchicine, and plants with chromosome numbers ranging from 7 to 42 were obtained, some of which were backcrossed to barley. North American Barley genotypes are being tested for anther culture response. Barley genome mapping using RFLPs was initiated.

GRAIN CROP PRODUCTION AND QUALITY RESEARCH REVIEW

Commodity: Barley
Management Unit Representative: Robert L. Burton
Management Unit: Wheat and Other Cereal Crops
Location: Stillwater, Oklahoma

Objectives/Approach:
The objectives of the Stillwater barley program are to reduce the impact of biological stresses of barley through development of pest-resistant germplasm for use in an integrated pest management system; to adapt a molecular marker based system of identifying gene products conferring host plant resistance to pests for germplasm improvement applications; to develop an immunoassay screening technique for identification of sources of resistance in barley germplasm; to determine inheritance of genes controlling resistance; to transfer resistance genes from selected barley germplasm into adapted genotypes for release to public and private breeders.

Cultivated and related barley species exhibiting resistance to the Russian wheat aphid (RWA) and prevalent greenbug biotypes will be identified by conventional screening methodology. Once differentials have been identified, biochemical and physiological mechanisms of resistance will be characterized and molecular and/or cellular markers associated with resistance will be identified and characterized. Relationships between markers and resistance response will be established through genetic analysis protocols. Immunoassay-based screening protocols will be developed based on gene products conferring resistance. Genetic control and inheritance patterns of resistance genes will be determined through genetic analysis of segregating populations. Transfer of resistance genes will be made through conventional hybridization methodology using breeding strategies formulated from information obtained from inheritance studies. RWA-resistant germplasm will be incorporated into a future integrated pest management system for cereals on the Great Plains.

Status of Research:
Several sources of resistance to the RWA have been identified in *Hordeum vulgare* accessions from southwest Asia and in related *Hordeum* species. Crosses have been made between several RWA-resistant lines and malting barley cultivars. Studies are ongoing to determine the genetic control of the resistance sources used in these crosses. Interspecific crosses have been made between RWA-resistant *H. bulbosum* and malting barley cultivars, embryos rescued, and hybrid plants regenerated. All of the hybrids exhibited RWA resistance. Selected hybrid plants are being used for attempts at backcrossing to *H. vulgare*. Characterization of differential responses to RWA feeding damage in resistant and susceptible plant types is underway through silver staining of denatured leaf proteins and *in vivo* radiolabeling of RWA-induced protein synthesis visualized by isoelectric focussing polyacrylamide gel electrophoresis. Detailed analysis of physiological and biochemical mechanism of resistance are underway.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Barley
Management Unit Representative: Darrell Wesenberg
Management Unit: Small Grains and Potato Germplasm Research
Location: Aberdeen, Idaho

Objectives / Approach:

Barley research at Aberdeen and Tucson includes three principal areas of emphasis: germplasm enhancement with the focus on pedigree, recurrent selection, and other approaches involving cytogenetics, tissue culture, and wide crosses; National Small Grains Collection (NSGC) germplasm collection, maintenance, and distribution; and coordination and conduct of barley germplasm evaluation. Specific objectives include enhancement of barley germplasm to develop desirable gene combinations with emphasis on both regional and national needs; definition of genetic mechanisms of determination of qualitative and quantitative traits; and maintenance of genetic stocks of barley and other small grains. Maintenance and worldwide distribution of seed of Hordeum accessions in the NSGC and maintenance of passport and evaluation data in the Germplasm Resources Information Network (GRIN) are the principal objectives of the NSGC program. The third area of emphasis involves the conduct of a coordinated and systematic evaluation program designed to obtain specific agronomic, physiologic, disease, quality, and insect reaction data for NSGC accessions and related germplasm.

Status of Research:

The barley tissue culture research program has completed the initial characterization of the in vitro response of 15 elite genotypes. Cooperative studies involving ARS personnel at Stillwater, OK and OSU personnel at Corvallis, OR have lead to the identification of hybrid plants between Hordeum vulgare and H. bulbosum that possess resistance to the Russian Wheat Aphid. Preliminary agronomic studies indicated that an 18-chromosome barley was competitive with adapted cultivars in seed weight and plant dry weight. Improved germplasm from recurrent selection populations have been used to develop several short-strawed, high-yielding cultivars. Special purpose cultivars being released from Tucson include 'Seco' and 'Solum' as well as the high beta-glucan content 'Azhul'. Pedigree approaches have resulted in the release from Aberdeen of a number of malting barley cultivars, including the recently recommended 'Russell' NSGC Hordeum accession samples totaling 56,834 were distributed worldwide from the National Small Grains Germplasm Research Facility (NSGGRF) in 1990. Systematic evaluation of NSGC accessions was coordinated by NSGGRF staff during 1990. Cooperative evaluations were conducted for resistance to Russian Wheat Aphid, barley yellow dwarf virus, barley stripe mosaic virus, and spot and net blotch of barley. The Aberdeen staff has been involved in the entry of NSGC evaluation data into the GRIN system and initiation of cooperative evaluations of NSGC barley accessions and other elite germplasm for reaction to stem rust race QCC in North Dakota and Puerto Rico and similarly for reaction to barley stripe rust race 24 in Bolivia under the direction of Colorado State University staff.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Barley
Management Unit Representative: Kurt Leonard
Management Unit: Cereal Rust Research Unit
Location: St. Paul, Minnesota

Objectives/Approach:
Research on barley at the Cereal Rust Lab involves two projects. Objectives of the epidemiology project are to monitor stem rust epidemics in barley, determine the virulence characteristics of rust populations, and identify resistance to important races of the stem rust fungus. Similar research is planned for barley stripe rust if it spreads to the United States from Mexico, where it causes severe damage. The general objective of the physiology project is to understand the physiological, biochemical, and molecular genetic bases of race-specific and general resistance in cereals using barley powdery mildew as a model system. Specific objectives are: 1) to identify host response genes triggered early in induced resistance reactions and determine when and where they are expressed, and 2) to characterize changes that occur in cellular membranes, cytoskeleton, and mitochondria in response to infection. Host tissue will be treated with inhibitors of protein and RNA synthesis at intervals before inoculation to determine when critical elements of the host response are activated. Cytoplasmic events in host response are monitored with video enhanced microscopy of living barley cells in a microculture system. Strongly expressed host response genes are identified in cDNA libraries from leaves sampled at intervals after inoculation. Labeled anti-sense mRNA from cloned host response genes will be hybridized to tissue sections from inoculated leaves to identify cellular sites of active resistance response. Anti-sense RNA or specific ribozymes will be injected into cells before inoculation to block the expression of specific host response genes and assess their importance in the overall resistance response.

Status of Research:
Barley is attacked by two forms of the stem rust fungus: the rye form and the wheat form. Since 1990, the search for stem rust resistance in barley has concentrated on the wheat form, because a new race of the fungus virulent on all American barley cultivars appeared in the Great Plains in 1989. Surveys showed that this race survived the 1989-90 winter on susceptible winter wheat cultivars in Kansas. The epidemiology project will continue to monitor survival and spread of this race as well as that of the rye form of stem rust on barley. The physiology project identified marked changes in the cytoplasm of resistant leaves inoculated with powdery mildew. In plants with the mlo resistance gene, cytoplasm of epidermal cells aggregates at the site of fungal attack and deposits papillae that physically impede penetration by the fungus. Plants with the Mla resistance gene respond with a hypersensitive reaction in which the initially invaded host cells die and inhibit further parasitic growth of the fungus. In this response, cytoplasmic streaming stops in the attacked cells, and 1-2 hr later, the cells collapse. Host cell collapse is generally preceded by collapse of the cell nucleus, suggesting that the cytoskeletal structure around the nucleus breaks down before cell death. Cytochalasin B, which modifies microfilaments and patterns of cytoplasmic streaming, inhibits the hypersensitive response and permits parasitism by the fungus. Preliminary results indicate that the fungal mitochondria are rendered inactive before host cells collapse in the hypersensitive response. Permeability of host cell membranes is also disrupted shortly before cell collapse in these leaves.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Barley
Management Unit Representative: Robert Olien
Management Unit: Sugarbeet, Bean and Cereal
Location: East Lansing, Michigan

Objectives/Approach:

Objectives for this project lead toward identification of natural cold hardiness systems that have evolved in cultivated winter cereals and related species, especially those systems that might give significant increments to the hardiest commercial cultivars. The objectives involve thermodynamic analysis of freeze stress and biochemical characterization of protective traits so that hardiness limitations can be expressed on a functional basis and in molecular terms. Adaptive systems that protect plants from freeze injury at crown temperature approaching -10°C are the least understood and the most relevant to crop improvement. Our analysis of freeze dynamics indicates that strong adhesive interactions between ice and hydrated plant substances cause this injury. Immediate objectives involve the modifying effect of intercellular solutes on interfacial tension between ice and the protoplasmic membrane: Specifically, cryomicroscopic quantitation of freeze injury as a function of adhesive energy, and biochemical characterization of adaptive changes induced by freezing in hardy plants. A more general objective involves quantitation of variances in freeze stress patterns that develop in fields of commercial crop production and distinguish hardy cereal species and cultivars.

Status of Research:

Adaptive relaxation of interfacial tension
A perfusion technique that quantitatively determines the amount of solute in the intercellular liquid of plants, was developed to identify the biochemical activities induced by freezing that adapt plants to adhesive stress. Release of sucrose and fructose into the intercellular liquid by hydrolysis of fructan was found to relax interfacial tension and promote survival at crown temperatures near -10°C. Features that determine these carbohydrate distribution patterns in hardy plants are being defined for genetic research.

Freeze inhibitors
Pure arabinoxylan freeze inhibitors were isolated and their composition analyzed with support for cooperative research with Paul Kindel, MSU biochemist, from the USDA Competitive Grant Program. Freeze inhibitor activity of the pure substance is affected by interaction with other polymers and solutes. Substances that would stimulate or depress freeze inhibitors activity are being sought for manipulation of freeze kinetics as an aspect of hardiness that we find important during midwinter thaw-freeze cycles.

Environmental variance
Winter kill in fields of cereal production reduces the plant density in irregular patterns that are difficult to predict. Aerial photographs indicate that snow erosion by wind and sun is a major factor of environmental variance. Hardiness requirements for a successful cultivar are functions of environmental sequences that affect specific field sites, which if known, identify the limiting aspects that need improvement.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Barley
Management Unit Representative: David Peterson
Management Unit: Cereal Crops Research
Location: Madison, Wisconsin

Objectives/Approach:
Research on barley at the Cereal Crops Research Unit is directed primarily towards improvement of malting quality, with a secondary focus on nutritional quality. The objectives encompass both basic research and evaluation of breeders' samples. Objectives of basic research for malting quality are divided among three projects: 1) to determine the regulation of enzymes involved in starch degradation, 2) to purify and characterize proteases and protease inhibitors in barley and malt, and 3) to understand gene regulation for enzymes important to the malting process. A key element of the barley quality program is the malt quality analysis service, which is essential to the progress of all public malting barley breeding programs in the US. Samples are micromalted, and the barleys and their malts are analyzed for about a dozen malting quality traits. The data are used by the breeders and by the malting and brewing industry in their process of approving cultivars. Another area of research is the investigation of tocotrienols which are inhibitors of cholesterol synthesis and are especially abundant in barley. Their effects on lipid metabolism in humans and experimental animals are being investigated through collaborative arrangements.

Status of Research:
The roles of α-glucosidase in native starch degradation have been determined. The major contribution of α-glucosidase is via its interaction with α-amylase. These two enzymes together result in *in vitro* starch hydrolysis rates comparable to *in vivo* rates. Previously, the importance of α-glucosidase had not been recognized. A 30 KD endoprotease has been purified and characterized from green malt and its specificity determined by hydrolysis of hordothionins, small proteins of known amino acid sequence. Other proteases and protease inhibitors are being isolated, purified and characterized. The activities of these proteases and inhibitors during malting and mashing will determine the protein/peptide/amino acid ratios in wort and beer. Gene regulation in malt has been studied by comparing gene expression in two barleys of differing quality, Morex and Steptoe. Genes and gene products are similar in both genotypes, but are formed more slowly in Steptoe. This is true even in the presence of added gibberellin, indicating that Steptoe may have a defective gibberellin receptor. Electrophoretic procedures for barley cultivar identification, using hordein proteins or esterase isozymes, have been developed. These procedures are particularly needed, because malting barley, unlike other grains, is marketed by cultivar. About 4000 barley samples are malted and analyzed annually, and data returned to the breeders. These samples include the regional nurseries in addition to early generation breeders' samples. Advanced, promising selections are pilot brewed and the beer analyzed for quality. All new barley cultivars produced by public breeding programs have been evaluated in this manner in this laboratory. Tocotrienols from barley, high-protein barley flour, and brewers' spent grains have been shown to inhibit HMG-CoA reductase, the rate limiting enzyme of cholesterol biosynthesis, and to lower total- and LDL-cholesterol in humans and experimental animals.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Barley
Management Unit Representative: Albert L. Scharen
Management Unit: Cereal Crops Improvement Research Unit
Location: Bozeman, MT

Objectives/Approach:
Barley research at Bozeman has three broadly defined objectives: (1) To conduct basic research on fundamental problems in genetics, biochemistry and molecular biology; (2) To develop and improve germplasm for diverse barley growing regions of the U.S.A. and (3) Determine biology and control measures for barley diseases. Research areas include: barley transformation; adaptation to stress; nutritional and malting quality; mechanisms of the control of gene expression during growth and development; elucidation of mechanisms regulating metabolism; genome characterization or genome mapping. Methods include: identification of useful genes in exotic germplasm and their transfer to useful germplasm; the development of novel methods of genetic analysis useful in barley improvement; the isolation and characterization of structural genes and the proteins they encode and the isolation and characterization of regulatory genes that control structural gene expression.

Status of Research:
One scientist position is currently vacant. The recruitment process is underway for a new scientist who will address the program outlined in the preceding paragraph. Recent results of the previous program, concluded in August, 1990 by retirement of the incumbent scientist, include: (1) seed set on male sterile plants, compared in USA and Norway, was satisfactory for production of hybrid barley; (2) barley stripe mosaic virus (BSMV) was eliminated from composite cross populations by use of ELISA serology and elimination of infected plants; (3) the cultivars "Bearpaw", a 2-rowed, high yielding, high malting quality barley and "Haybet", a new forage barley, were released to farmers.

Polymerase chain reaction (PCR) protocols were developed for the diagnosis of net and spot forms of *Pyrenophora teres*. Low copy number sequence selected from a *P. teres* f. sp. *maculata* random genomic library were used as a source of probes. These results demonstrated the potential of PCR as a diagnostic tool for *P. teres*, and as a powerful means of determining relationships among plant pathogens.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Oat

Management Unit Representative: Howard Rines

Management Unit: Plant Science Research Unit

Location: St. Paul, Minnesota

Objectives/Approach:

The objectives of the oat genetics research project at St. Paul are to develop genetic manipulation technologies for oat and to produce genetically enhanced germplasm to improve oat production efficiency and grain quality. Approaches include: 1) Development and utilization of cell culture technologies to produce haploids, select mutants, and introduce recombinant-DNA; 2) Application of molecular genetic technologies to develop a DNA molecular marker (RFLP) map in oat, associate markers with agronomic and quality traits for selection and manipulation, and clone genes for specific traits; 3) Production and release of agronomically enhanced germplasm containing new sources of disease resistances, reduced plant height, hullessness, and backcross-substituted alien cytoplasms; and 4) Evaluation of oat accessions from the National Small Grains Collections for smut and crown rust resistance and other traits for data entry into GRIN and coordinate Regional Unifom Early and Midseason Spring Oat Nurseries.

Status of Research:

Haploid oat plants have been produced by wide cross hybridization (oat X maize) using embryo rescue techniques following elimination of maize chromosomes during early embryo development. Aneuploid (chromosome-deficient) progeny obtained from these haploids are being used to develop monosomic (2n-1) stocks for use in developing a genetic map in oat. Numerous oat cDNA probes have been cloned and DNA extracted from monosomic, nullisomic, and F_1 monosomic plants as initial efforts in a large cooperative oat RFLP genome mapping project. Seven probes have been located to chromosome to date. Backcross-derived oat lines are being screened for associations between crown rust resistance genes and RFLP markers. Oat callus and embryonic shoots with both transient and stable expression of introduced recombinant DNA marker genes have been recovered, but no genetically transformed fertile oat plants have yet been obtained. Oat lines with new sources of crown rust resistance from diploid and tetraploid oats species will soon be ready for germplasm release. About 1000 oat accessions from the National Small Grains Collection have been evaluated for snut and crown rust resistance with 1500 more to be evaluated this summer.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Oats

Management Unit Representative: Adrianna Hewings

Management Unit: Crop Protection Research Unit

Location: Urbana, Illinois

The cereal virus group at Urbana has three interrelated objectives: To investigate mechanisms of resistance to barley yellow dwarf virus, soilborne wheat mosaic virus and other economically important cereal viruses; to investigate the dynamics of cereal virus epidemiology; and to evaluate the response of cereal germplasm to economically important viruses and cooperate in cereal germplasm enhancement programs. Projects on oats include: 1. Identification and characterization of virus-encoded proteins responsible for pathogenicity by producing infectious *in vitro* transcripts from full-length cDNA copies of the viral RNA. Once an efficient or workable method for inoculations has been developed, naturally occurring variation in either field isolates or closely related strains of BYDV, *i.e.*, MAV and SGV, will be used to study pathogenicity. In addition to naturally occurring variability, variation will be introduced into the cloned cDNA by either deletion or site-specific mutagenesis to produce a broader spectrum of mutations. Recombinant viruses will be formed. 2. Identification and characterization of elected host and virus genes conferring resistance to viral infection through the identification of restriction fragment length polymorphism (RFLP) markers that can be used in breeding programs to follow tolerance genes and identification and characterization of the tolerance genes linked to the RFLP markers. 3. Determination of BYDV virus incidence in spring oat and winter wheat fields across the small grains production areas of Illinois. Leaf samples collected during May of each year are analyzed using a triple-antibody monoclonal enzyme-linked immunosorbent assay to determine incidence of BYDV by crop, cultivar, and location.

Status of Research:

An Illinois BYDV-PAV isolate has been extensively characterized. Full-length cDNA clones have been produced and their nucleotide sequence determined. Work is in progress to identify differences at the molecular level manifest either as restriction fragment length polymorphisms of viral cDNA or by nucleotide changes identified by either S1-protection assays or by direct nucleotide sequence analysis. As differences are identified, the biological significance of these alterations will be evaluated by producing recombinant viruses between the laboratory and field isolates containing only the suspected region(s) from the field isolate. Plants will then be reinfected the recombinant virus and the phenotype observed

The incidences of BYDV-PAV serotypes in randomly selected samples ranged from 0-40% in oat fields in 1989, and 0-50% in 1990, from 0-2% in wheat fields in 1989 and 0-40% in 1990. The incidences of BYDV-RPV serotypes ranged from 0-6% in oat fields and from 0-2% in wheat fields. No field samples were positive for BYDV-MAV serotypes in either year. A subsample of individual leaves that tested positive for BYDV was used to establish a collection of isolates to determine natural biological and molecular variability

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Oat
Management Unit Representative: Norman D. Williams
Management Unit: Cereal Crops Research
Location: Fargo, North Dakota

Objective/Approach:
The mission of the Cereal Crops Research Unit at Fargo is to provide basic knowledge and improved germplasm for developing, maintaining, and improving hard red spring wheat, durum, barley, and oat. The major oat objective is to develop an understanding of oat fiber quality, distribution, regulation, inheritance, and utilization. Methods for determining oat fiber quantity, including total dietary fiber, soluble fiber, insoluble fiber, and beta-glucans, will be evaluated. Lipase and peroxidase activities and their effects on quality of oat bran will be investigated. Differences among oat cultivars and breeders elite lines will be evaluated in relation to physical quality of oat groats, environmental factors, and processing parameters. Bran fractions will be incorporated into baked products and evaluated for rheological and product performance.

Status of Research:
This is a new project, and most available funds have been used for purchasing equipment and supplies, and establishing a Specific Cooperative Agreement with North Dakota State University for hiring a postdoctoral scientist to initiate the research. A postdoctoral scientist was hired, and research was started in January, 1991. Research has been initiated to determine the influence of environment on chemical composition of oat groat and the effect of environment on the partitioning of carbohydrate into starch and fiber by oat.

GRAIN CROP PRODUCTION AND QUALITY

RESEARCH REVIEW

Commodity: Oat

Management Unit Respresentative: Robert Olien

Management Unit: Sugarbeet, Bean and Cereal

Location: East Lansing, Michigan

Objectives/approach:

Objectives are similar to those stated for barley in that they lead toward identification of natural cold hardiness systems that might give significant increments to the hardiest commercial cultivars. The objectives involve thermodynamic analysis of freeze stress and biochemical characterization of protective traits so that hardiness limitations can be expressed on a functional basis and in molecular terms. Immediate objectives involve characterization of adaptive responses to low temperature and freezing that distinguish oat cultivars from barley, wheat, and rye.

Status of Research:

Injury caused by strong adhesive interaction between ice and hydrated plant substances at a crown temperature approaching $-10^{o}C$ is the most relevant problem for improvement of hardiness in barley. Survival depends on adaptive relaxation of interfacial tension by sugars generated from fructan hydrolysis. Similar stress seems to limit hardiness of oats, but carbohydrates in oats follow a different pattern of redistribution than they do in barley and wheat in response to chilling and freezing. Patterns of carbohydrate distribution are being analyzed in cooperation with D. Livingston to characterize distinctive features that prevent oat cultivars from attaining the hardiness of barley and rye.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Oat
Management Unit Representative: Darrell Wesenberg
Management Unit: Small Grains and Potato Germplasm Research
Location: Aberdeen, Idaho

Objectives / Approach:

Oat research at Aberdeen includes three principal areas of emphasis: germplasm enhancement employing both traditional and molecular approaches; National Small Grains Collection (NSGC) germplasm collection, maintenance, and distribution; and coordination and conduct of oat germplasm evaluation and enhancement. Specific objectives include enhancement of oat germplasm to develop desirable gene combinations with emphasis on both regional and national needs; initiation of a linkage map of oat and determination of linkages or associations of molecular markers with economic genes in oat; and definition of genetic mechanisms of determination of qualitative and quantitative traits. Maintenance and worldwide distribution of seed of Avena accessions in the NSGC and maintenance of passport and evaluation data in the Germplasm Resources Information Network (GRIN) are the principal objectives of the NSGC program. The third area of emphasis involves the conduct of a coordinated and systematic evaluation program designed to obtain specific agronomic, physiologic, disease, quality, and insect reaction data for NSGC accessions and related germplasm as well as coordination of a national germplasm enhancement program.

Status of Research:

A linkage block of two isozyme loci and one RFLP locus has been identified. Twenty-six oat cultivars, including six Avena species were surveyed for electrophoretic variation of twelve isozyme systems. Polymorphisms were detected among cultivars and among species for all the systems surveyed. Pedigree approaches have resulted in the cooperative release or pending release of a number of oat cultivars, including 'Ajay' and 'Rio Grande'. NSGC Avena accession samples totaling 7,944 were distributed worldwide from the National Small Grains Germplasm Research Facility (NSGGRF) in 1990. Systematic evaluation of NSGC accessions was coordinated by NSGGRF staff during 1990. Cooperative evaluations for resistance to barley yellow dwarf virus (BYDV), smut, and rust continued along with evaluations for beta-glucan, protein, and oil content. The Aberdeen staff has also been involved in the entry of NSGC evaluation data into the GRIN system; field or laboratory taxonomic classification of over 8,000 NSGC oat accessions; and quarantine and field grow out of 893 new accessions of Avena sativa from a collection made in Turkey in 1986. A National Oat Germplasm Enhancement Plan, developed by the Oat Crop Advisory Committee was implemented in 1990. The enhancement effort will focus on five critical areas: nutritional quality, BYDV tolerance, rust resistance, lodging resistance, and grain yield. The Northwestern States Oat Nursery was coordinated at Aberdeen and nearly 5,000 small grains entries were increased for 18 ARS and State projects in 14 states.

GRAIN CROP PRODUCTION AND QUALITY

RESEARCH REVIEW

Commodity: Oats (Winter)

Management Unit Representative: Steven Leath

Management Unit: Plant Science Research

Location: Raleigh, NC

Objectives/Approach:

Approximately 20% of the cereal pathology effort at Raleigh is spent on winter oats with the primary emphasis on germplasm enhancement in cooperation with the state breeder. Projects on winter oats include: 1) Screening the winter oat germplasm for resistance to the PAV and MPV strains of barley yellow dwarf virus in conjunction with A. Hewings, USDA-ARS, Urbana, IL, using paired hill plots and artificial inoculation. 2) Screening winter oat and *Avena sterilis* germplasm for resistance to oat mosaic caused by oat golden stripe and oat mosaic virus by planting germplasm in infested soil at nursery sites and evaluating germplasm for symptom expression and virus titer. 3) Determining the distribution and yield reducing effects of oat mosaic in the Southeast using surveys and paired hill plots, respectively. Yield loss studies compare plots in infested soils with those in non-infested soil and to ones that are treated to eliminate the fungal virus vector. 4) Determining the role of cool-season *Pythium* spp. and *Rhizoctonia* spp. on the winter survival of oats using field plots in the piedmont and mountain regions of NC and systemic fungicide treatments.

Status of Research:

All entries in the winter oat uniform and hardiness nurseries, as well as released material, were screened for BYDV resistance. Differences are great across entries and the work will be expanded and repeated. Similarly, differences exist in oat mosaic resistance and some *A. sterilis* accessions show useful levels of resistance and may be suitable for breeding programs. Studies at two locations are underway to relate symptom expression to yield loss with oat mosaic. Survey data from commercial fields throughout North Carolina in 1990 and 1991 is complete and being compiled. Similar data from Georgia in 1990 also are available. Multiple years of study indicate that *Pythium* spp. infect oats within 48 hr of planting and are a factor in winter oat survival as are other fungi, but to a lesser extent. Genotype x environment interaction is large with these studies and data do not fully explain the variations observed. Cooperative germplasm efforts involve inoculations and evaluating numerous entries for crown rust resistance and a cultivar release has been initiated.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Oat
Management Unit Representative: Kurt Leonard
Management Unit: Cereal Rust Research Unit
Location: St. Paul, Minnesota

Objectives/Approach:
The Cereal Rust Research Group conducts research on epidemiology and genetics of oat stem rust and crown rust with three primary objectives: 1) monitor progress of oat rust diseases nationally and estimate annual yield loss to rust, 2) characterize genetic variation for virulence within and between regional populations of oat rust fungi and determine the basis for virulence shifts in rust populations, and 3) identify sources of resistance to oat stem rust and crown rust. The resistance project evaluates oat entries in the NSGC for adult plant resistance to crown rust in a field nursery lined with hedges of buckthorn, the alternate host for the rust fungus. Oat lines in the nursery are exposed to a genetically diverse population of the fungus, because the sexual cycle and genetic recombination in the crown rust fungus occur on buckthorn. Resistance to stem rust will be tested with oat seedlings in the greenhouse. Epidemics of oat rusts are analyzed where they occur to identify environmental and cultural factors that influence their severity. Isolates of stem rust and crown rust are collected for analysis of intra- and interpopulation variation in virulence genes. Host-parasite coevolution is simulated in computer models to identify conditions that can account for equilibria between host resistance and rust virulence in natural populations of wild cereals and their associated rust fungi. Competition among pathogenic rust races will be analyzed to determine natural selection coefficients associated with virulence genes in crown rust on susceptible and resistant oats.

Status of Research:
Analysis of oat stem rust survey data showed that stem rust epidemics in the north central states are initiated by rust spores from infected oats in the southern plains. Severity of stem rust in the north central states each year was more closely related to the date of rust onset than to spring and summer weather conditions in those states. The decreased damage of oat stem rust in recent years was related to declining acreage of oat production. Preliminary reconstructions from serial EM sections of pachytene nuclei showed that the oat crown fungus has $n = 17$ chromosomes. Field isolates of the oat crown rust fungus were shown to have large numbers of virulence genes (>30 on average) including many that correspond to resistance genes that have never been used commercially in American oat cultivars. Frequencies of specific virulence genes differ between populations in northern and southern states, indicating that separate regional epidemics of oat crown rust are initiated from different inoculum sources in northern and southern states. Computer simulations of host-parasite coevolution showed that polymorphisms for virulence and avirulence in rust populations and for resistance and susceptibility in wild cereal populations can be stable if there is some fitness cost to the fungus associated with unnecessary genes for virulence. Polymorphisms were more stable in the competition version than in the hard selection version of the model.

GRAIN CROP PRODUCTION AND QUALITY RESEARCH REVIEW

Commodity: Oat
Management Unit Representative: David Livingston
Management Unit: Pasture Research Laboratory
Location: University Park, PA

Objectives/Approach:

The primary objective of this project is to determine the genetic and physiological basis for freezing tolerance in winter oat. Specific goals include: a.) determining the relationship of fructan to freezing tolerance, b.) determining the effect of barley yellow dwarf virus (BYDV) on carbohydrate accumulation and freezing tolerance and c.) improvement and evaluation of spring oat germplasm.

Controlled freezing tests and HPLC analyses are being conducted to determine how fructan and simple sugars change before and during freezing and to see if those changes are related to the low level of freezing tolerance in winter oat. The same kinds of tests are being performed on BYDV infected and noninfected oats to determine how the virus affects carbohydrate composition and freezing tolerance. Greenhouse crossing and field evaluation are being used to improve existing spring oat germplasm for grain yield, bushel weight and disease resistance. Single-seed descent is being used to advance populations during fall and winter.

Status of research:

In contrast to other winter cereals we found that winter oat accumulated much lower amounts of high degree of polymerization (DP) fructan during hardening. It was also found that sugar increase during a -3°C treatment after hardening (a phenomenon observed in the field and shown to increase low temperature survival) was significantly lower in oat. Results from controlled freeze-tests suggest that this may be one reason oat is so susceptible to low temperature injury.

A procedure was developed which will allow screening of a large number of plants for fructan content. The procedure is being used to screen existing oat germplasm for fructan and to conduct a genetic analysis of fructan accumulation.

An automated, microprocessor-controlled device was developed which simulates the efficiency of manual collection of liquid chromatographic fractions. This device is being used to collect fructans of varying DP in pure form which will be used as substrates in enzyme studies in an attempt to discover why oat does not accumulate high DP fructan.

We found that BYDV infected plants accumulate significantly less DP>3 fructan but significantly more sucrose and monosaccharides. There was no difference between infected and non-infected plants for DP3 fructan. Enzymatic studies have been initiated to see if/how the virus is affecting fructan synthesizing enzymes. Freeze tests measuring the effects of different types of freezing stresses are being conducted to see if BYDV infection affects the physiological or cytological response of plants to freeze damage.

In the germplasm evaluation program high-yielding, white-seeded lines have been identified in replicated tests. Several lines with consistently high bushel weight in national tests are being considered for germplasm release. Crosses are being made between BYDV, leaf and crown rust resistant lines and susceptible high yielding and high bushel weight lines.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Oat
Management Unit Representative: David Peterson
Management Unit: Cereal Crops Research
Location: Madison, Wisconsin

Objectives/Approach:
The objectives of oat research in the Cereal Crops Research Unit are to improve quality through physiological and biochemical studies of grain development and metabolism and to evaluate and enhance germplasm for quality characteristics. Research objectives are currently focused on the characterization and synthesis of endosperm cell wall polysaccharides. These polysaccharides, of which ß-glucan and arabinoxylan are predominant, have particular beneficial characteristics in human physiology such as the lowering of LDL-cholesterol and ameliorating the effects of Type II diabetes. Understanding their characteristics will assist nutritional research in learning how these fibers affect lipid and other metabolism in animals, and will be useful for plant breeders in producing new oat cultivars with value-added traits. Breeders' samples are evaluated for protein by NIR analysis. It is hoped that with the addition of new NIR instrumentation, this service can be extended to other constituents, such as oil and ß-glucan. The National Small Grains Collection of oats is being screened for ß-glucan by flow-injection analysis methodology, to identify high ß-glucan germplasm for plant breeders and for future research to determine the regulation of ß-glucan concentration.

Status of Research:
Procedures for fractionation of oat endosperm cell walls were developed, and these fractions have been characterized by digestion with specific polysaccharide hydrolases and analysis of the products with HPLC and GC. Arabinoxylans are the predominant carbohydrate polymer, followed by ß-glucans. The ß-glucans are linear polymers of glucose with 1τ3 and 1τ4 bonds, and these bonds occur in a different proportion than in barley ß-glucan. The ratio of 1τ3 to 1τ4 bonds was similar in a survey of 12 cultivars, but differed widely among Avena species. A flow-injection analysis system was assembled and evaluated for use in screening the oat collection for ß-glucan. An experiment was performed to evaluate genotype and environmental effects on ß-glucan concentration. Although a significant interaction was obtained, rankings of cultivars among locations were generally similar, especially for high and low ß-glucan samples. It was concluded that analysis of the Aberdeen-grown samples from the oat collection would adequately identify most high ß-glucan germplasm. As of March 1, 1991, about 1000 samples from the collection have been analyzed. ß-Glucan levels vary about 2-fold from 3.5 to 7%, and no extremely high samples have been found. In the past, considerable research on characterization of oat storage proteins was done, but that project is not currently active. Approximately 10,000 breeders' samples are analyzed yearly for protein. The bulk of these are early- to mid-generation breeding selections, but many are from research projects. Methods for identifying oat genotypes by electrophoresis of avenins have been worked out and have been proven useful in several instances where the identity of seed lots was uncertain. These same techniques are being extended to a study of the inheritance of specific avenin polypeptides.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Oats
Management Unit Representative: Dwayne Buxton
Management Unit: Field Crops Research Unit
Location: Ames, Iowa

Objectives / Approach: Genetics of resistance to fungal pathogens in cereals

The overall objective of this program is to investigate the basic genetics and molecular biology of host-pathogen interaction in small grains. We have two interrelated projects in this area. The first is to genetically map genes for crown rust resistance in oats with the aid of RFLP markers. The immediate application would be the availability of these markers to breeding programs for marker assisted breeding strategies. The long term goal is to develop a map based cloning system for the cloning of oat genes. Another related project is the construction of a high density map of the region around the *Ml-a* powdery mildew resistance locus in barley. The objective in the *Ml-a* project is to not only make markers available to breeders but to set up a system where chromosome walking may be feasible.

Status of Research:

In the fall of 1990 we screened 35 races of crown rust on 33 differentials and the seven diploid oat accessions that have been chosen for mapping. 14 additional race screenings are in progress. In the two main mapping populations; CI 2630 (*Avena strigosa*) x CI 9009 (*Avena nudibrevis*) and CI 3815 (*Avena strigosa* x *Avena wiestii*) nearly all races showed a distinct polymorphism for rust reaction. Iowa State University cooperators have been screening libraries for low copy polymorphic probes. F_2 seeds have been planted in growth chambers in conditions for maximum yield for F_3 families. Approximately six genes for crown rust resistance will be mapped in the F_2; the remainder will be mapped in F_7 single seed descent lines.

Initially, we are screening 1000 F_2 segregates from crosses between the CI 16151 (*Ml-a6*) and CI 16155 (*Ml-a13*) isolines. About 10 map units of introgressed region surrounds the *Ml-a* locus in these lines. *Ml-a* is flanked by *Hor1* and *Hor2*, barley endosperm storage protein loci. By scoring for recombination between the storage protein loci, we can generate recombinant stocks surrounding the *Ml-a* locus. We hope to generate 100-200 recombinant stocks representing a crossover point every 0.1 centimorgan. These recombination points will be ordered using a combination of powdery mildew inoculations, RAPD and RFLP markers, and clones for the hordein loci.

GRAIN CROP PRODUCTION AND QUALITY RESEARCH REVIEW

Management Unit Representative: R.H. Dilday

Management Unit: Rice Production and Weed Control Research Unit

Location: Stuttgart, Arkansas

Objectives/Approaches:

The rice germplasm and weed control group has three major objectives: Evaluate and develop new, improved and existing germplasm (USDA/ARS Rice Collection), genetic populations, and breeding stocks adapted to the Southern Rice Belt. Identify and enhance germplasm having increased resistance to herbicides, allelopathy, disease-insect pests, lodging and tolerance to stresses combined with greater grain and milling yields and nutritive value; and develop biological agents for weed control and economical, integrated weed management systems for rice and rotated crops. Individual projects include: 1. Systematic evaluation and characterization of the rice portion of NSGC. The initial research was focussed on characterizing the collection (16,059 accessions) for 11 basic plant characters; whereas, the present emphasis is focussed on evaluating the collection for allelopathic activity to weed species; genetic mechanisms that influence germination, emergence and stand establishment; and tolerance to herbicides, salt, drought and disease. 2. Genetic studies to determine mode of inheritance of allelopathic activity in rice to aquatic weeds, herbicide resistance and physiological diseases (straighthead). 3. Determination of chemical, biological, and cultural methods that can be integrated into improved weed management systems for rice and rotated crops.

Status of Research:

Approximately 216,000 rice accessions have been characterized or evaluated since 1984 for allelopathic activity to ducksalad (Heteranthera limosa), purple ammannia (Ammannia coccinea) and broadleaf signalgrass (Brachiaria plalyphylla); herbicide resistance to Alachlor (Lasso) and Glyphosate (Roundup) for red rice control; tolerance to straighthead, bacterial leaf blight, salt and drought; and plant characters such as days to anthesis, plant type, plant height, panicle type, grain type, hull cover, sterile lemma color, awning, lodging and seed coat color. Rice accession that possess allelopathic activity to ducksalad and purple ammannia, tolerance to alachlor and glyphosate and resistance to straighthead have been identified and genetic studies have been initiated. Germplasm has been identified that is very responsive to gibberellic acid (GA_3). Treating the seed with GA_3 will approximately double the mesocotyl/coleoptile elongation potential of most semidwarf rice germplasm which promotes better emergence and stand establishment. This technology has been transferred to a commercial company and up to 20% of the rice acreage in the U.S. will be seeded to GA_3 treated seed in 1991. Also, the technology is being utilized commercially on an international basis as a management tool for rice.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Rice
Management Unit Representative: Darrell Wesenberg
Management Unit: Small Grains and Potato Germplasm Research
Location: Aberdeen, Idaho

Objectives / Approach:

The Management Unit objectives concerning rice primarily involve the storage and distribution of seed of National Small Grains Collection (NSGC) rice accessions and the maintenance of data in the Germplasm Resources Information Network (GRIN). The Management Unit cooperates in the evaluation and enhancement of NSGC rice accessions. Seed of NSGC rice accessions are distributed worldwide. The NSGC curator serves as an ex officio member of the Rice Crop Advisory Committee (CAC).

Status of Research:

The NSGC rice collection, totaling over 16,000 accessions, is housed in the National Small Grains Germplasm Research Facility at Aberdeen. NSGC rice accession samples totaling 33,973 were distributed to numerous scientists worldwide in 1990. The entire rice collection was repackaged and reinventoried following completion of the Rice Rejuvenation Project. Kernel weight determinations were completed at Aberdeen in 1990 for approximately 10,000 accessions. The Management Unit will cooperate in the determination of bran color of all NSGC rice accessions, since red bran is a highly undesirable contaminant in commercial rice fields. The NSGC Curator has been an active member of the Rice CAC, regularly participating CAC and other rice research meetings.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Rice
Management Unit Representative: Antoinette A. Betschart
Management Unit: Food Quality Research Unit
Location: WRRC, Albany, CA

Near-Infrared spectroscopy (NIR) has been studied as a method for assessing rice quality as indicated by amylose content. NIR spectral regions have been found which contain information associated with amylose content. Progress has been made on developing a prediction equation for amylose. The rice industry will supply representative samples of milled rice for addition to the calibration file and NIR instrument manufacturers will participate in application of this information to their equipment. Differential scanning calorimetry (DSC) is being used to assess starch and lipid properties for application in extrusion and other processing systems.

Rice flour is being used as a standard medium to better understand the factors which control the texture of twin screw extruded products. This information will be used in developing new rice containing products made by cooker-extrusion technology. Single screw extruders are being used to assess the influence of temperature, moisture, and heating time on the stability and availability of components in rice bran which may influence cholesterol status.

Nutritional studies are in progress using hamsters as a model to determine the components in rice bran which may reduce serum and liver cholesterol levels as well as improve the LDL : HDL ratio. Various lipid and fiber components are being investigated. Results will be compared with those from feeding components of other cereal grains (oats, barley, wheat).

GRAIN CROP PRODUCTION AND QUALITY RESEARCH REVIEW

Commodity: Rice

Management Unit Representative: W. M. Dowler

Management Unit: Foreign Disease-Weed Science Research Unit

Location: Frederick, Maryland

Objectives/Approach:

A major part of our mission is to gain advance information about foreign/exotic diseases which have the potential to damage U.S. crops. We import foreign pathogens under permit, conduct studies in a containment greenhouse, and work with cooperators to learn all we can about the disease under field conditions. Current objectives include studies of Xanthomonas diseases of rice and genetics of the rice blast pathogen *Magnaporthe grisea (Pyricularia oryzae)*.

We are conducting comparative studies of bacterial blight (*Xanthomonas oryzae* pv. *oryzae*) and bacterial streak (*X. campestris* pv. *oryzicola*) of rice. Approaches include development of rapid methods for accurate identification, comparisons of virulence, and methods of inoculation. Several methods of characterizing variation within and between pathovars (including isozymes, polyclonal antibodies, and carbon source utilization) are being compared.

Several strains of M. grisea are being crossed to determine heredity of selected characters to gain information regarding the stability of this pathogen.

Status of Research:

Isozyme analysis, substrate utilization, and polyclonal antibody comparisons indicate there is considerable variation in the bacterial blight pathogen in different regions of the world. For example, the pathogen in Texas is very different from populations in Asia.

In a majority of crosses studied between transformants and wild type parents, 1:1 ratios were observed for segregation of hygromycin resistance, indicating segregation as a single locus. Some rearrangements of integrated DNA have also been observed.

GRAIN CROP PRODUCTION AND QUALITY

RESEARCH REVIEW

COMMODITY: Rice

MANAGEMENT UNIT REPRESENTATIVE: Bill D. Webb

MANAGEMENT UNIT: Rice Research Unit

LOCATION: Beaumont, TX (*Crowley, LA)

Objectives/Approach: Rice Variety/Germplasm Improvement for Southern USA requires a multidisciplinary approach to (1) develop broadly useful high-yielding rice varieties utilizing available and emerging techniques; (2) identify value-added qualities for transfer into marketable varieties; (3) conduct basic investigations in breeding methodology, host-parasite disease reactions, grain quality identification; (4) improve productivity/quality of ratoon rice; (5) develop insect control by selective germplasm, chemical/biological methods (Crowley). The breeder (vice), geneticist, entomologist (vice), pathologist, chemist work as a team. The Unit's ultimate goal is development of improved varieties/germplasm, but much research involves: genetics and physiology; broad range of rice qualities; important rice diseases, insects, and their control; development of screening tests; new cellular and molecular technology, and their application to breeding.

Increasingly higher costs of production places US rice at a disadvantage in international/domestic trade causing loss of significant markets. The situation is serious with ca 20% of U.S. rice producers dropping out of farming. Reducing per unit cost of production through breeding can be approached by developing (1) varieties that produce high yields without equivalent increases in production costs, (2) value-added varieties that command premium prices or that satisfy specific consumer needs, (3) varieties resistant to disease, insects or stress conditions so less pesticides are required, (4) varieties with high main crop yield combined with better ratooning ability as ratoon crop requires little additional production inputs.

Status of Research: Conventional and value-added varieties released by the unit are grown on over a million acres throughout TX, LA, AR, MS, MO, and FL. They include the first Southern long-grain semidwarf Lemont; Gulfmont, like Lemont, with better ratoon potential; Rexmont, with superior processing qualities; Rico 1, a high yielding medium-grain with superior ratoon yields; Texmont, an anther culture-derived semidwarf with superior ratoon yields; Jasmine 85, a soft-textured aromatic developed at IRRI; Dellmont, an aromatic firm-textured semidwarf identical to Lemont except for flavor.

To further increase yields without increasing production costs, crosses were made with Gui Chow and Tequing, record high-yielding but poor quality Chinese varieties. From these, lines with good grain shape and quality are in 1991 yield trials. Anther culture and RFLP technology was recently added. By concentrating on known AC responsive materials, callus production and regeneration rates will be increased to produce several hundred AC-derived pure lines for breeding and other studies in 1991. Correlations between 60-100 RFLP's and agronomic and quality traits are being sought to identify QTL's.

Diseases of greatest concern are sheath blight and rice blast and breeding lines are continually evaluated to improve resistance. Research is underway on improved screening techniques, heritability of resistance and quantifying effects of weather/cultural conditions on disease incidence/severity. Selections are also evaluated for unusual susceptibility to other diseases as brown leaf spot, narrow brown spot, panicle blight, straighthead, kernel smut.

Identifying quality in conventional long-, medium-, short-grain rices for varietal improvement in TX, LA, AR, MS, CA is now on a routine basis; with much effort directed to developing more efficient screening tests. Basic research in identifying qualities of value-added rices particularly those associated with appearance, texture, taste, flavor is in progress.

Rice water weevil and stinkbug are the most important insect pests. While at present there are effective chemical controls for both pests, research continues in evaluating rice germplasm for stinkbug/water weevil resistance and experimental insecticides for primary and secondary pest control.

Quality, disease, insect, anther culture and RFLP evaluation projects to assist varietal improvement programs in TX and/or LA, AR, MS, CA are continuing.

*The Crowley SY position for this project has been vacant since August, 1989, and is scheduled for revision August, 1991.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Sorghum

Management Unit Representative: Kenneth P. Vogel

Management Unit: Wheat, Sorghum, and Forage Research Unit

Location: Lincoln, Nebraska

Objectives/Approach:

Research is focused on improving productivity, stability of production, and profitability of sorghum in the central Great Plains with basic and applied research in 4 areas: germplasm evaluation, enhancement, and breeding, mechanisms of drought and temperature stress tolerance, tolerance to mineral element deficiencies, and sorghum diseases. Long term goals are to develop germplasm with improved value-added quality attributes and improved tolerance to biotic and abiotic factors.

Status of Research:

Drought and Heat Stress: Recent research has emphasized studies on the accumulation of metabolites during drought and temperature stress such as abscisic acid, proline, and osmotic agents, particularly sugars. It has been demonstrated that exogenously applied ABA increases seedling desiccation tolerance, growth in the absence of stress, and grain yields of stressed plants.

Sorghum Pathology: The potyviruses infecting sorghum are being characterized using an array of biology, serology, and molecular biochemistry procedures. Traditional biological procedures has shown different host ranges and 8 different host reaction types for the viruses. Serological and biochemistry analyses reveals four different viruses with several strains of each. Methods have been developed for screening for host resistance to each virus.

Sorghum Mineral Deficiency Tolerance: Genotypic differences for Fe, P, and N deficiency and Al and Mn toxicity and factors and mechanisms associated with these differences were determined. Improved procedures for screening for genetic differences in mineral element deficiencies have been developed. Mechanisms of genetic control of mineral uptake and tolerance have been investigated.

Sorghum Germplasm Improvement: Quantitative genetic procedures were evaluated for their relative efficiencies in improving populations and germplasm. Current focus is on improving feed quality of sorghum grain and forage and on improving stress tolerance of sorghum germplasm. Near Infrared Reflectance Spectroscopy (NIRS) calibrations have been generated that will be used in germplasm evaluation and enhancement research on quality.

GRAIN CROP PRODUCTION AND QUALITY

RESEARCH REVIEW

Commodity: Sorghum

Management Unit Representative: Keith Schertz

Management Unit: Crop Germplasm Research Unit

Location: College Station, Texas

Objectives/Approach:

The objectives of the sorghum germplasm project are: (1) Develop germplasm evaluation techniques to identify sources of diversity. (2) Evaluate and identify sources of diversity. (3) Determine the inheritance of characteristics and map their controlling loci. (4) Enhance germplasm and develop lines and populations for release to public and private scientists. Acquisition efforts focus on parts of the world from which only a limited number of accessions have been obtained. Evaluation priorities are on reproductive and molecular characteristics. Inheritance studies include cytoplasmic as well as nuclear controlled characteristics. Cytogenetic stocks are developed and employed in many of the genetic studies. Germplasm and genetic stocks that possess useful genes are increased, described, and released, and those of most immediate interest to breeders are registered.

Status of Research:

Through cooperation, Chinese scientists have provided 385 landraces. This germplasm, from an area poorly represented in the National Germplasm System, has the potential to provide improved cold and drought tolerance. The genetic and cytogenetic stocks, maintained in this program, are being increased for deposit at NSSL. Twenty-one new sources of cytoplasm that induce male sterility have been identified, and we have proven that at least six of these differ from the standard cytoplasm and from each other in their mode of sterility induction. They provide possible assurance against a cytoplasm-specific hazard and also the opportunity to increase the nuclear diversity of hybrids through the development of new female parents. The nuclear inheritance of fertility restoration is now a subject of inquiry.

The isozyme diversity in a broad spectrum of germplasm is being determined. Included have been over 400 entries, including U.S. breeding lines, hybrids, introduced lines, African landraces, and wild races. The most conserved were the U.S. lines and the most diverse were the wild races, indicating the availability of additional diversity. At present the isozyme diversity of the Chinese landraces and of lines introduced through the USDA/Texas A&M Conversion Program is being assessed. Cooperative genome mapping studies have been commenced. We are identifying and providing the germplasm, including the mapping population; and are developing progeny for the mapping of molecular markers to useful genes. We are now mapping isozyme loci to RFLP markers. Other progeny we are developing include those for mapping of apomixis and cytoplasmic-nuclear male sterility.

We are now using the trisomic and translocation stocks we developed to assign molecular markers to specific chromosomes. Germplasm with the potentially most useful male-sterility-inducing cytoplasms have been released and registered. One cytoplasm that induces sterility in nearly all lines is being used in breeding programs to facilitate testing potential female parents with superior combining ability. Studies for the future include identifying cytoplasms by mitochondrial diversity, genome mapping, and marker-assisted selecting.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Sorghum

Management Unit Representative: B. R. Wiseman (for R. E. Lynch, RL)

Management Unit: Plant Resistance/Germplasm Enhancement Research Unit

Location: Tifton, Georgia

Objectives/Approach:

The plant resistance project has several interrelated progressive objectives as follows: 1) develop sorghum with resistance to insects; 2) determine the mechanisms and biochemical/biophysical bases of the resistance; 3) determine the effectiveness of the resistant germplasm in reducing losses to insects in low-input, sustainable agricultural systems; 4) determine the interaction of plant resistance to insects with other methods of control.

Status of Research:

SGIRL-MR-1 through -4 grain sorghum and Tift MR88 forage sorghum germplasm lines have been developed and released at Tifton with resistance to the sorghum midge. SGIRL-MR-1 was the first released source of sorghum germplasm resistant to the sorghum midge in the U.S. Fifty-six additional germplasms/inbred grain sorghum lines with resistance to the sorghum midge were developed and released cooperatively with Texas A&M University at Lubbock. The genetics of the resistance to the sorghum midge has been established to be at least two recessive genes in the earlier sorghum releases. Insect resistance methodology and technology have been developed and reported. Three parasitoids have been identified that are associated with the sorghum midge; Aprostocetus diplosidis is the primary parasite in the Tifton area. Three hundred thirty-six converted sorghums have been studied extensively for resistance to the fall armyworm. The converted sorghums were evaluated for resistance to FAW in the seedling, mid-whorl, late-whorl, early-flower, soft-dough, and hard-dough stage of development. Several genotypes were identified with resistance at one or more stages of plant development, and a new type of nonpreference resistance was identified. All three mechanisms of resistance, nonpreference, antibiosis, and tolerance were delineated in the converted sorghums.

Research will continue to focus on the identification and development of new germplasm with resistance to the most important sorghum insect, the sorghum midge, and the fall armyworm, the corn earworm, and the sorghum webworm. The mechanisms of resistance and the biochemical/biophysical bases of the resistance will be studied. Also, the resistant sorghum cultivar will be studied as it interacts with other control measures, such as parasites and insect pathogens, to demonstrate its impact in reducing losses to insects in a low-input, sustainable agricultural system.

Commodity: Sorghum
Management Unit Representative: Daryl R. Pring
Management Unit: Plant Stress and Protection Research Unit
Location: Gainesville, Florida

Objectives/Approach:

Objectives of the research unit include elucidating nuclear-cytoplasmic interactions associated with cytoplasmic male sterility (cms), develop, examine biology and exploit tissue culture systems, and establish fundamental aspects of expression of agronomic genes in sorghum. The research approach includes exploiting polymorphic gene coding regions or expression variation among genetically distinct sources of cms, the cloning and sequencing of identified genes, and identifying a role(s) these sequences may play in cms and potential vulnerability to pests. Stability of nuclear and cytoplasmic gene coding regions are examined in tissue culture systems. Genes encoding functions of carbohydrate metabolism in somatic cells and during seed development are being examined to evaluate role(s) in developmental regulation and stress physiology.

Status of Research:

Investigations of cms concentrate on cytoplasms which are being differentiated and characterized by ARS efforts at College Station, TX, and which exhibit differential fertility restoration behavior. Near-isogenic lines of the A1-A4 groups in the maintainer line Tx398, partially restored F1's, and the original source of the cytoplasm are used with specific gene coding region probes to examine polymorphisms and expression of mitochondrial genes in sterile and fertile states. Several polymorphisms are under study, including a second copy of the atp6 gene in the A1, A2 and A3 groups. A common copy of the gene is found in all sorghums examined to date, and the additional copy results from a duplication/recombination event within the open reading frame. The two copies thus differ 5' to the recombination breakpoint, exhibiting divergent amino terminal regions, promoters and regulatory sequences. One male fertile cytoplasm examined to date exhibits this second copy of the gene. Transcription of the genes in some cytoplasms are differentially affected by nuclear background, one of which is a fertility restorer of the cytoplasm. In other cases we have observed general background effects on transcription which are unrelated to fertility restoration. RNA editing, a process by which nucleotides predicted by DNA sequence are changed in transcripts, is extensive in the sorghum mitochondrion. We have examined editing by reverse transcriptase, PCR, cloning, and sequencing of cDNAs. The mitochondrial atp6 and atp9 genes are each truncated by the appearance of a new stop codon resulting from editing, eliminating 3-12 amino acids at the carboxy terminus predicted by genomic sequences. Fifteen amino acids of atp6 are changed by editing, while seven are changed in atp9. Edited cDNA clones are being cloned in expression vectors to make authentic gene product for antibody production and examination of expression of genes during microsporogenesis.

Cell suspension cultures from three cultivars have been obtained. These cultures have been used to prepare protoplasts which divide readily and can regenerate callus. Long term culture of cell suspension and suspensions from protoplasts were analyzed to study the molecular nature of somaclonal variation. We have determined that such variability, unlike gene mutations, is non-random in nature. An unusually high level of genomic variability, stable for numerous cell generations, is associated with repeated DNA elements..

Two sucrose synthase isozymes, SS1 and SS2, are encoded by the two non-allelic genes, Sus1 and Sus2, respectively. Although these two genes and their products share significant similarity with maize genes, several differences in regulatory properties are readily detectable between the two species. Collective data indicate that the SS isozymes play an important role in developmental processes and stress physiology.

GRAIN CROP PRODUCTION AND QUALITY RESEARCH REVIEW

Commodity: Sorghum

Management Unit Representative: Larry D. Dunkle

Management Unit: Crop Production and Pathology Research

Location: West Lafayette, Indiana

Objectives/Approach: The long-range goal of the research on sorghum in this project is to establish the function of genes that determine resistance to fungal pathogens by investigating host-pathogen interactions that are controlled by single genes in the host and that are influenced by host-specific toxic metabolites produced by the pathogen. The specific objectives are to: (1) determine the structure and activity of the toxin (PC-toxin) produced by the root rot pathogen *Periconia circinata*; (2) determine the site and mechanism of action of the toxin; and (3) establish the role of the toxin in pathogenesis.

Status of Research: The chemical structures have been determined for the three major host-specific toxins produced by pathogenic isolates, a non-toxic precursor which accumulates in culture medium of non-pathogenic isolates, and some inactive synthetic analogs. Studies on structure-activity relationships established certain structural requirements for biological activity against susceptible genotypes. Current research is directed toward: determining the pathway and enzymes involved in biosynthesis of the toxins; and determining the activity of the toxins and their analogs against weed species of *Sorghum* (e.g., shattercane and Johnsongrass).

PC-toxin induces alterations in gene expression resulting in the enhanced synthesis of a set of charge isomers of a 16-kD protein and the respective mRNAs only in susceptible genotypes of sorghum. These alterations were shown to be strictly associated with the lethal effects of the toxin. Recent efforts have concerned purifying the proteins to: (1) obtain amino acid sequence information for preparation of oligonucleotide probes to isolate the genes encoding the proteins and (2) produce antibodies for immunochemical localization of the proteins at the tissue and cellular levels.

Studies designed to determine the primary site of toxin action have indicated that susceptible, but not resistant, genotypes contain a proteinaceous toxin receptor or binding site at the cell surface or plasma membrane. We have adapted methods for tagging membrane proteins and have obtained evidence for a toxin-binding protein, a likely candidate for the *Pc* gene product which determines susceptibility to *P. circinata*. This protein will be isolated, purified, and sequenced to derive nucleotide sequences for isolation of this disease response gene.

In studies on the role of PC-toxin in the host-pathogen interaction, we found that elicitation of phytoalexins in roots did not prevent the action of PC-toxin and did not prevent infection of roots by the fungus, suggesting that susceptibility induced by the toxin over rides the resistance reponses induced by elicitors.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Wheat

Management Unit Representative: E.H. Coe Jr.

Management Unit: Plant Genetics Research Unit

Location: Columbia, Missouri

Objectives / Approach:
The wheat genetics group at Columbia has three interrelated major objectives to its program: to develop new methodology and to improve the efficiency of existing methodology for the manipulation of alien gene complexes in wheat for practical application; to investigate the approaches for monitoring the insertion of alien gene complexes into a wheat background; and to analyze the expression of the alien gene complexes when present in a wheat background. Some projects currently under investigation are: 1. To develop two new aneuploid stock sets utilizing modern high yielding wheats. The selection of the wheat parents was based on the worldwide adaptability of the varieties and their genetic makeup (i.e., high crossability and tolerance to heavy metals). 2. To develop the methodology for producing physical maps of the location of small (1 kb or less) DNA probes. This will be used for detecting the location of alien inserts in wheat as well as cloned wheat genes of interest. 3. To utilize *in situ* hybridization and RNA analysis to study the expression levels of alien genes that are present in wheat backgrounds. 4. To isolate DNA probes from alien species that are genome-specific and will not cross-hybridize with wheat. These will help in identifying alien DNA when it has been placed in wheat.

Status of research:
From three to six backcross generations have been made in order to create the new aneuploid stocks. At the present time only seven generations will be done before the material is released for public use and for our own research programs involving gene expression. Several DNA probes that are specific to *Aegilops speltoide* have been isolated and are being used to study the evolution of the B genome of wheat. In addition, the B genome donors contain many genes of agronomic value for wheat production and the probes can be used as markers to track the valuable genes as they are inserted into cultivated wheat. An *in situ* hybridization technique has been developed that allows for mapping the physical location of DNA probes as small as .8 kb in size. This technique is currently being used to produce physical maps of recombinational linkage maps.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Wheat
Management Unit Representative: Norman D. Williams
Management Unit: Cereal Crops Research
Location: Fargo, North Dakota

Objectives/Approach:
The mission of the Cereal Crops Research Unit at Fargo is to provide basic knowledge and improved germplasm for developing, maintaining, and improving hard red spring (HRS) wheat, durum, barley, and oat. Major wheat objectives are: 1) investigate the genetics of host-pathogen relationships, morphological and agronomic traits, and end-use quality factors through conventional genetic, cytogenetic, and breeding procedures; 2) develop germplasm and genetic or cytogenetic stocks for use in genetic analyses and breeding improved cultivars through conventional and innovative genetic and breeding procedures; 3) induce mutations for improving agronomic, rust resistance, and quality traits through use of chemical mutagens; 4) introgress desirable genes form related species through wide crosses and use of conventional and modern cytogenetic, genetic, and breeding techniques; 5) develop pest (stem rust) genotypes to identify host genes for resistance using hybridization and mutation procedures; 6) evaluate wheat and processing quality of samples of hard red spring and durum wheat through measurements of kernel characteristics, milling performance, and end-product quality; and 7) investigate physical and biochemical properties, especially of carbohydrates (starch), fibers, and enzymatic activity (peroxidase), as related to end-use quality of HRS and durum wheat.

Status of Research:
Tests with a recombinant stem rust race showed that HRS cultivar Len had 1 gene, Coteau 2 genes, and Stoa 3 genes for resistance not present in Waldron; another gene in Coteau was effective at 22 C. and not at 28. EMS-induced mutations of a suppressor on chromosome 7D allowed expression of suppressed stem rust resistance genes; stem rust resistance of a second mutant was conditioned by a single, incompletely dominant gene on chromosome 5D and of a third mutant by a hemizygous ineffective, recessive gene. Homoeoallelic chlorina mutants on the long arm of group 7 chromosomes of durum and hexaploid wheat are being used to investigate the photosynthetic mechanism and as genetic markers. Stem rust resistant amphiploids of hexaploid and durum wheat with Aegilops speltoides and Triticum dicoccoides were produced; a durum line developed with a telosome from T. speltoides had immunity to stem rust. Substitution of T. dicoccoides chromosomes, especially 6B which conditions high protein content, into durum showed high promise for improving several agronomic and quality traits. Homozygous recombinant chromosome lines are being produced for genetic mapping with RFLPs and quantitative and qualitative traits. A set of dimonotelosomic lines of durum wheat are being produced to supplement valuable sets of durum aneuploids. Several wheat hybrids incorporating alien (Triticeae grasses) genomes S, J, E, N, P, I, JE, and JN were produced as promising sources of pathogen resistance and tolerance to salt and drought. Wheat quality analyses of 1659 HRS and 1227 durum samples from U.S. breeders were evaluated in 1990. Spring Wheat Quality Advisory Council samples of 23 HRS wheats from 4 locations were milled on the pilot mill, evaluated, and flour was distributed to 21 collaborators for evaluation. Gluten index was unsuitable for quality evaluation of breeders samples. Peroxidase activity for screening early generation material for quality is being investigated. Starch characteristics of HRS and HRW wheats are being evaluated for variations in amylose/amylopectin components and starch granule size.

GRAIN CROP PRODUCTION AND QUALITY RESEARCH REVIEW

Commodity: Wheat
Management Unit Representative: Robert L. Burton
Management Unit: Wheat and Other Cereal Crops
Location: Stillwater, Oklahoma

Objectives/Approach:
The objectives of the cereals unit at Stillwater are to develop cereal germplasm with inherent protection against insects, diseases, and environmental stresses; define biological and cultural control methods; and, improve agroecosystem management systems. Research targets are Russian wheat aphids (RWA), greenbugs, and wheat foliar diseases. Projects include: 1. Host Plant Resistance--Identify resistance sources, study the nature of resistance, and assist in gene transfer to new germplasm. 2. Germplasm Development--Identify, characterize, and introgress resistance genes for germplasm enhancement. 3. Biological Control--Collect, study, and release native and exotic natural enemies of cereal pests, including insects and diseases. 4. Alternate Hosts--Identify and characterize resistance genes in hosts related to cereals. 5. Simulation Modeling--Develop quantitative technology for incorporation into management decision support systems.

Status of Research:
The Plant Science Research Lab continues to successfully develop the technology needed to overcome the seriousness of cereal pests in the United States. Several hundred lines that are resistant to RWA have been located in the USDA-ARS National Wheat Collection. Thirty of these have been chosen for further testing and introgression into advanced germplasm. We have found that RWA differs biotypically between regions of the world, which will affect the future of our plant resistant programs. New natural enemies of the RWA are being located internationally and returned to the United States for evaluation and release. Continuing studies on the biology, ecology, physiological damage, and alternate hosts of RWA and studies on the biological control of foliar diseases all have been successful. The development of an integrated pest management system for the future will utilize all of the technology currently under development.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Wheat
Management Unit Representative: Gary M. Banowetz
Management Unit: Forage Seed and Cereal Research Unit
Location: Corvallis, Oregon
Objectives / Approach:
The wheat physiology research program at Corvallis has the following objectives:
1. Identify molecular changes which occur during the transition of the plant from vegetative to reproductive growth. Selected electrophoretic methods have been used to determine whether specific changes in meristem polypeptides signaled evocation.
2. Determine whether cytokinins, or other plant hormones, play a role in this transition. Cytokinins in leaves were identified and quantified using monoclonal antibody-HPLC methods to determine whether changes in these growth regulators correlated with photoinduction processes in the leaf. Genes which code for anti-zeatin antibody chains were inserted into tobacco plants to determine whether expression of these antibodies would deprive the plants of cytokinins at specific stages of development. Tobacco was chosen as a model because of the relative ease of gene insertion and because cytokinins have been implicated in flowering processes in this plant. 3. Characterize the interactions between light, phytochrome, and cytokinins during growth and development of the wheat plant. Cultivars have been screened to identify genotypes which respond differently to light and exogenous cytokinin treatment. In addition, nitrate reductase expression is under study as a model of an enzymatic system affected by light, phytochrome, and cytokinins.
Status of Research:
Electrophoresis of meristem polypeptides did not identify evocation-specific changes in gene expression. At this time, it seems that more sophisticated techniques will be required to study evocation processes. It is likely that evocation-specific gene expression results in relatively rare sequences which will be difficult to detect by these methods. Subtractive hybridization of cDNA libraries from induced and non-induced plants followed by use of polymerase chain reaction (PCR) may help amplify these rare signals and increase the likelihood of their detection. No induction-specific changes in the types or quantities of cytokinins have been detected by monoclonal antibody-HPLC techniques. Consequently, a collaborative project has been set up to insert anti-zeatin antibody genes in tobacco plants to determine whether expression of these genes within the plant will deprive the plant of certain cytokinins at specific developmental stages. Currently, the genes have been inserted into the plants and studies are underway to characterize the expression of these antibody genes in tobacco plants. This should serve as a model for eventual use in wheat and other cereals. A cultivar of wheat with altered responses to light and cytokinin treatment has been identified. Cytokinin and phytochrome levels within plants of this cultivar under selected light regimens are currently being characterized.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Wheat (and rice)
Management Unit Representative: Autar K. Mattoo
Management Unit: Plant Molecular Biology Laboratory
Location: Beltsville, Maryland

Objectives / Approach:

In order to improve yield and nutritional quality of cereals (rice and wheat) and produce crops resistant or adaptable to environmental (chemical) stresses and fungal diseases, the interdisciplinary team research at PMBL, Beltsville is focused towards understanding and unraveling: a) The key rate-limiting reactions regulating metabolic processes such as photosynthesis, essential pathways (biosynthesis of lysine, methionine, threonine, and the hormone, ethylene), and protein turnover; b) the molecular basis for plant resistance to fungi with special reference to host-pathogen interactions, host defense systems and the disease-inducing factors in virulent strains of pathogens; c) the cellular targets of heavy-metal toxicity and UV/high light irradiation; and d) d the development of tissue culture technology for the recovery of haploids and double haploids with unique variation, and the application of cDNA, RFLP and antibody probes as biochemical-molecular markers for detection of various stresses and diseases.

Status of Research:

Haploids and doubled haploids of wheat and rice were recovered from their anther cultures, yielding dozens of plants per spike. *In vitro* inhibitor selection techniques resulted in rice mutant lines rich in lysine, similar to the high lysine opaque-2 maize mutant. The work produced high lysine (15% greater than control) rice germplasm with increased protein content and shorter flowering times. Future studies are geared at elucidating the molecular basis for the high lysine phenotype. The signal that targets the D1 photosystem II reaction center protein for rapid turnover in the light, including the UV, was identified as phosphorylation of the N-terminal threonine residue at position 2 . This process seems to be a protective mechanism that chloroplasts use against damage in the light. Oxidative stress and senescence, induced by cupric ion toxicity, caused rapid degradation of ribulose-1,5-bisphosphate carboxylase. Its inactivation and degradation were correlated with -Cys_{247}-Cys_{247}- intermolecular cross-linking and translocation to plastid membranes. This protein is a major factor contributing to photosynthetic efficiency during plant growth as well as nitrogen re-distribution during senescence. Genetic variability between different isolates of the wheat pathogen, *Stagnospora nodorum,* and of the rice blast fungus, *Pyricularia* is being analyzed using DNA fingerprinting and methylation studies. We are also investigating the basis for and the role of transcriptional activation of chitinases and proline-rich glycoproteins as a means of host defense against infection and wounding stress. Finally, we are selecting for gene(s) associated with disease resistance in wheat line resistant to *Septoria tritici.*

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Wheat
Management Unit Representative: Darrell Wesenberg
Management Unit: Small Grains and Potato Germplasm Research
Location: Aberdeen, Idaho

Objectives / Approach:

Wheat research at Aberdeen includes three principal areas of emphasis: germplasm enhancement with the focus on molecular biology and improvement of stress tolerance in wheat germplasm; National Small Grains Collection (NSGC) germplasm collection, maintenance, and distribution; and coordination and conduct of wheat germplasm evaluation. Specific objectives include the identification of cereal genes regulating tolerance to osmotic stress due to drought and salinity; isolation and characterization of the structure, function, and regulation of genes conferring stress tolerance; and the enhancement of wheat germplasm for drought/salinity tolerance by genetic engineering. Maintenance and worldwide distribution of seed of Triticum accessions and related species in the NSGC and maintenance of passport and evaluation data files in the Germplasm Resources Information Network (GRIN) are the principal objectives of the NSGC program. The third area of emphasis involves the conduct of a coordinated and systematic evaluation program designed to obtain specific agronomic, physiologic, disease, and insect reaction data for NSGC accessions and related germplasm.

Status of Research:

Field experiments are underway to evaluate the performance of salt tolerant wheat genotypes under dryland vs. irrigated conditions, comparing the response of ten salt tolerant wheat genotypes vs. ten salt sensitive wheat genotypes. The NSGC wheat collection, totaling over 42,000 accessions, is housed in the National Small Grains Germplasm Research Facility (NSGGRF). NSGC wheat and related accession samples totaling over 39,000 were distributed worldwide in 1990. Systematic evaluation of accessions in the NSGC was coordinated by NSGGRF staff at Aberdeen during 1990. Data on field descriptors have been obtained on approximately 35,500 wheat accessions during the 1983-90 period. Cooperative evaluations for resistance to Russian Wheat Aphid, Hessian fly, barley yellow dwarf virus, stripe rust of wheat, and dwarf bunt continued along with cooperative evaluations of ploidy analysis of Triticum species. In addition to the ongoing evaluation program, the Aberdeen staff has been involved in the entry of NSGC evaluation data into GRIN; growth habit evaluations of 10,000 NSGC wheat accessions; grow out and taxonomic evaluation of over 600 NSGC spring wheat accessions; and increase and evaluation of a spring wheat germplasm collection derived from a series of interspecific crosses completed by Mr. William J. Sando in the 1930s. Location funds were also used to partially support the evaluation of Pioneer Seed Company developed hard red winter wheat germplasm at Manhattan, Kansas. Specific Cooperative Agreements or within ARS Fund Transfers involving such cooperative evaluations and related research for all small grains currently involve over 20 University and ARS projects in at least 16 states.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Wheat (Soft Red Winter)

Management Unit Representative: Steven Leath

Management Unit: Plant Science Research

Location: Raleigh, NC

Objectives/Approach:

To determine the epidemiology and yield reducing effects of powdery mildew and leaf rust of wheat in the Southeast, to develop a simulation model for wheat growth and epidemic development for southeastern conditions, to determine the genetic basis of powdery mildew-wheat interactions including identification of resistance genes and determination of virulence gene frequency in *Blumeria graminis* f. sp. *tritici* populations; to introgress powdery mildew and Septoria leaf and glume blotch resistance from wild relatives into hexaploid wheat; to develop in vitro callus selection methods for resistance to *Septoria nodorum*. Genetic studies involve characterized isolates and pure genetic material in controlled conditions and disease and yield assessment studies, as well as population genetic studies, are completed in the field with endemic pathogen populations. Virulence analyses rely on differential lines in both mobile nurseries and in spore traps. Introgression work involves both interspecific and intergeneric crosses and embryo rescue onto tissue culture media. Quantification of somaclonal variation for agronomic and disease resistance traits, both between and within calli of soft red winter wheat cultivars is in progress. Toxin extraction for callus selection involves solvent extractions and flash chromatography purification with thin layer chromatography verification.

Status of Research:

The role of powdery mildew in reducing wheat yields and the relationship between crop growth stage, disease levels and subsequent yield reduction has been detailed; the combined effects of leaf rust and powdery mildew on wheat development and yield are underway. Both deterministic and simulation models relating these factors are being developed. The virulence characteristics of the *B. g.* f. sp. *tritici* population in North Carolina have been determined and are being updated and the study expanded to a regional basis. Major soft red wheat cultivars are being analyzed to determine which, if any, powdery mildew resistance genes they carry. Determination of critical virulence thresholds that can be associated with subsequent epidemics on cultivars with specific resistance genes are in progress. Plants in the BC_1F_2 and BC_2F_2 generations have resulted from introgression of powdery mildew and glume blotch resistance from wild relatives (*Triticum monococcum, Aegilops squarrosa*, and *T. araraticum*) into hexaploid wheat via embryo rescue techniques. Somaclonal variation arising from between and within calli of soft red winter wheat cultivars is being quantified and toxin selected calli also are being evaluated for glume blotch resistance under field conditions. The USDA-ARS International Winter Wheat Powdery Mildew Program continues as a substantial portion of this project. In addition, germplasm enhancement and cooperative cultivar development efforts, as well as numerous other studies also continue and joint germplasm and cultivar releases are now in progress.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Wheat
Management Unit Representative: Antoinette A. Betschart
Management Unit: Food Quality Research Unit
Location: WRRC, Albany, CA

Projects in this unit on wheat include:

1. Improved Baked Products and Doughs with Extended Shelf Life.
2. Structure of Wheat Glutenin Proteins in Relation to Quality.
3. Image Analysis for Detection of Inclusions and Structure in Materials of Agricultural Interest.
4. Replacement of Petroleum-based Foams and Plastics with Biodegradable Wheat Starch Polymers.

Objectives / Approach:

1. Improve acceptance and shelf-life of frozen or refrigerated doughs and baked products by determining physical state of starch in model dough systems that have been refrigerated or frozen and subjected to a series of freeze-thaw cycles and by monitoring changes in water distribution / migration. Investigate the functionality of any new freeze-stable yeasts. Demonstrate new product concepts based on findings.

2. Relate specific glutenin proteins to wheat varieties with known quality characteristics. Determine structures of protein components responsible for mixing and baking quality. Use this information to facilitate quality improvement by genetic engineering techniques.
Status of Research:

3. Develop methods to detect foreign matter in cereals and other foods through techniques with film, digital X-ray radiography, or sound. Adapt these methods to detect and count inclusions in batch testing and in on-line quality control. Apply results to hidden insects in wheat and other grains.

4. Wheat flour, starch-rich milling streams, starch and starch derivatives will be expanded under controlled conditions of heat, pressure, and shear. The mechanical and thermal properties, microstructure, and biodegradability will be characterized. Binders from starch and starch derivatives will be used with small expanded starch products to produce molded foams.

Status of Research:

1. New project.

2. Glutenin subunits have been purified and partially sequenced, leading to identification of a new structural type of subunit which may affect quality by altering the MW distribution in native glutenin. Analysis of electrophoretic patterns and the mixing and baking quality of chromosome substitution lines provided new information about genetic loci that play a role in determining quality.

3. Recognition of insects from radiograms of insect infested wheat was measured as a function of insect type and age, and magnification. Recognition was related to cavity size in the kernel and insect type.

4. New project.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Wheat
Management Unit Representative: Frank C. Greene
Management Unit: Plant Development [Quality] Research Unit
Location: WRRC, Albany, CA

Objectives/Approach:
Wheat research in this Unit is conducted in two project groups, with general objectives to improve wheat quality characteristics by identifying and manipulating genetic factors that regulate seed yield, protein content and flour quality characteristics. These factors include control systems which regulate the general expression of seed storage (gluten) protein genes, the timing and specific localization of seed storage protein gene expression, the effects of environmental conditions on gene expression activity, and the relationships between gene or protein structure and dough functionality. Accomplishment of the objectives is being approached by: 1) characterization of the control of seed storage protein gene expression in relation to locus organization, chromatin physical structure, and specific DNA-nuclear protein interactions; 2) characterization of the molecular genetic control of nitrogen and carbohydrate assimilation, the nature and mechanism(s) of their influence on wheat yield and seed protein composition, and the effect(s) of environmental modulation of these mechanisms; 3) modification of the primary structure of HMW glutenin subunits to define the structural elements and physical properties important for dough improvement; 4) determination of the effect of environmental variations on levels of HMW glutenin subunit messenger RNAs; 5) determination of the nucleotide sequences that control responses to environmental variations, and construction and evaluation of chimeric genes with reduced sensitivity to such variations; 6) construction and screening of libraries enriched for genes that regulate the flowering phase of wheat plant development, and development of screening methods to differentiate winter and spring wheat varieties; 7) development of biotechnological strategies for wheat improvement through targeted genetic modifications.

Status of Research:
All of the High Molecular Weight glutenin subunit (HMW-GS) genes from the cultivar Cheyenne have been isolated and sequenced, as have several Low Molecular Weight glutenin subunit (LMW-GS) genes and several α-, β- and γ-gliadin genes. Putative Sucrose Synthetase gene clones are being characterized. Structural differences have been discovered between D-genome HMW-GS alleles associated with good and poor baking quality. HMW-GS protein secondary structure prediction analyses has generated a model consistent with the known protein physical properties, and identified regions of possible structural differences between subunits that may be related to differences in cultivar breadmaking performance. The effects of these predicted differences on HMW-GS physical properties is being examined in a protein expression system which permits the modification of genes, and production of the encoded proteins in the bacterium E. coli. Transient expression analysis of the promoter region of a HMW-GS gene in maize endosperm cells has identified a DNA sequence region that may be required for high-level expression of these genes, and resulting protein levels in the seed. In vitro gene modification and tissue culture transformation studies are underway. HMW-GS, but not α-gliadin, gene expression has been shown to decrease at elevated temperature, and an explanatory hypothesis for this phenomenon has been developed. A chimeric α-gliadin/HMW-GS gene designed for temperature insensitivity has been constructed, and attempts are underway to transfer this gene into wheat to test the hypothesis for HMW-GS temperature sensitivity.

Commodity: Wheat
Management Unit Representative: R.E. Allan
MU: Wheat Genetics, Quality, Physiology, and Disease Research Unit
Location: Pullman, WA

Objectives/Approach:

The wheat research unit at Pullman has four interrelated objectives. They embrace the disciplines represented in the MU, i.e. plant genetics, cereal chemistry, plant pathology, plant physiology and biochemistry. The inheritance of important traits especially quality parameters, resistance and tolerance or avoidance to biotic and abiotic stresses are studied. Special genetic stocks are developed to complement these studies and for use as parental material in applied breeding programs. Physiological research examines the elucidation of molecular, biochemical, and genetic events that regulate wheat seed dormancy and germination; determines the molecular mechanisms of wheat adaptation to environmental changes, with current focus on the role of the plant hormone ABA. Pathological research addresses control of foliar and smut diseases with emphasis on conducting and coordinating basic and applied research on rusts and smuts; approaches include forecasting epidemics, crop loss assessment, pathogen virulence, disease resistance, and integrated pest management. Quality studies concentrate on exploratory research of objective tests to define wheat market classes and quality evaluation of germplasm for several breeding programs. Suitability of wheat genotypes for domestic and foreign food uses is examined.

Status of Research:

Hormonal regulation of grain dormancy and drought tolerance: Differential screening for dormancy produced 16 cDNA clones for wheat genes expressed in hydrated dormant seeds. The protein products of the genes possess unique biochemical properties; all the proteins have high affinity for water. Sequestration of water aids in maintaining cellular integrity of partially hydrated seeds. The cDNA clones are being used to determine chromosome location of the genes and to develop potential genetic markers for wheat grain dormancy and drought-tolerance.

Control of cereal rusts and smuts: The evolution, distribution, differentiation and aggressiveness of stripe rust (SR) races is a main priority. Special host differentials have been used to detect 43 SR races and eight new undesignated genes for race specific resistance to SR were identified. Characterization and genetic regulation of durable SR resistance was elucidated; showed that this type of resistance was present in 80% of all PNW wheat cvs. Developed a predictive model based on temperature and rainfall that has consistently forecasted stripe rust epidemics in the PNW for several years.

Evaluation and improvement of wheat quality: The service research component annually evaluates 2000 to 3000 genotypes from several state, federal and industry wheat research programs. Samples are tested for their suitability for an array of domestic and foreign wheat foods. Improved methodology includes computer acquisition of moisture, ash, NIR, flour yield and mixograph; rapid assessment of starch particle properties; prediction of milling properties by the air pycnometer; and re-evaluation of pastry quality via AWRC and viscosity tests. Basic research is underway on starch granule-associated proteins as markers for grain texture; amylose/amylopectin ratio as to a prediction of noodle quality; and the genetic regulation of endogenous inhibitors of germination.

Wheat genetics and germplasm enhancement: Development of special genetic stocks is emphasized. Near isogenic lines (NILS) have been developed in 5 wheat market classes for major morpho-developmental wheat traits. Traits of these NILS include genes for vernalization, photoperiod, plant stature and other qualitative genes. Alloplasmic genetic stocks with 8 alien cytoplasms have been synthesized in 4 genetic backgrounds. Unique germplasm resistant to all of the diseases limiting early seeding, an effective way to control erosion, have been developed. New sources of resistance and/or tolerance to strawbreaker foot rot were transferred to adapted wheats; one line derived from Agropyron elongatum resists two soilborne diseases, three foliar diseases and has tolerance to BYD. Five soft white winter wheat cultivars were released since 1989. Their attributes include: coldhardiness, snowmold resistance, durable rust resistance, high resistance to foot rot and intragenotypic resistance to three foliar diseases.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Wheat
Management Unit Representative: Albert L. Scharen
Management Unit: Cereal Crops Improvement Research Unit
Location: Bozeman, MT

Objectives/Approach: Wheat research at Bozeman, Montana is described by three broad objectives: (1) Determine the epidemiology and pathogenicity of foliar pathogens; (2) Develop genetic, biological and cultural management strategies for control of foliar diseases; (3) Acquire new basic knowledge of cereal physiological and molecular genetics. Approaches include: Studies of pathogen variability in collections from many sources; determination of life cycles, means of survival and dissemination of pathogens; discovery of genes for resistance and transferring to adapted types of germplasm; identification, purification and characterization of enzymes involved in phytic acid synthesis; isolation and characterization of mutations that perturb phytic acid synthesis; using tools developed to clone genes in the phytic acid pathway; and genetic studies of the quantitative relationships among phytic acid and grain proteins and minerals.

Status of Research:
Septoria nodorum and *Fusarium* spp. from central Europe were categorized for pathogenicity, virulence and seed transmission in wheat, rye, barley, oat and triticale. Sixteen species of *Fusarium* were recovered from triticale. Seed transmission of *S. nodorum* was shown in 65% of kernels from inoculated plots of triticale. About 2300 lines of wheat were evaluated in the field for agronomic characters and disease resistance. In the glasshouse 630 lines were screened for resistance to *S. nodorum* and *S. tritici*. The international Septoria nursery was grown in 40 locations worldwide. Enzymatic studies of cereal inositol phosphate kinases continued. Methods were developed and are being used to screen, both at the level of pollen and seed, for mutations that perturb phytic acid synthesis. A study of the quantitative relationships between grain phytic acid, protein, and the minerals K, Mg, Ca, Fe, Mn and Zn is currently underway. A study of the role of DNA methylation continues. A completed work showed that grain phytic acid and total protein are highly correlated in winter wheat.

GRAIN CROP PRODUCTION AND QUALITY RESEARCH REVIEW

Commodity: Wheat

Management Unit Representative: W. M. Dowler

Management Unit: Foreign Disease-Weed Science Research Unit

Location: Frederick, Maryland

Objectives/Approach:

A major part of our mission is to gain advance information about foreign/exotic diseases which have the potential to damage U.S. crops. We import foreign pathogens under permit, conduct studies in a containment greenhouse, and work with cooperators to learn all we can about the disease under field conditions. Current objectives include the study of Karnal bunt and dwarf bunt (TCK) of wheat.

We have a cooperative project with CIMMYT/Mexico on Karnal bunt, caused by Tilletia indica, and the current emphasis is to determine the extent of pathogenic variation, develop an effective method for seed treatment, and develop a method for identifying the pathogen using DNA technology.

Dwarf bunt of wheat caused by Tilletia controversa is a perennial problem for wheat production in the Northwest. Teliospores of this fungus are morphologically similar to the common bunt fungus, T. caries, creating a trade problem because of mis-identification of spores. We are working jointly with Chinese counterparts to develop rapid, improved methods for identification.

Status of Research:

Potential differential lines of wheat are being inoculated with sporidial cultures of T. indica originally obtained from various regions of India and Mexico. A technique was developed to facilitate inoculum production with little shift in virulence.

A model was developed that uses morphological data for identifying T. controversa and T. caries in wheat samples. The model was developed jointly with Chinese scientists, and is presently being tested.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Wheat
Management Unit Representative: Kurt Leonard
Management Unit: Cereal Rust Research Unit
Location: St. Paul, Minnesota

Objectives/Approach:
The Cereal Rust Research Group conducts research on epidemiology and genetics of wheat rusts with four primary objectives: 1) identify new sources stem and leaf rust resistance in wheat, 2) monitor epidemics of wheat rusts nationally, 3) characterize genetic variation within and between regional populations of wheat rust fungi and determine the basis of virulence shifts in rust populations, and 4) develop molecular genetic approaches to identify, isolate, and analyze avirulence/virulence genes in wheat rust fungi. The resistance project evaluates wheat entries in the NSGC for seedling and adult plant resistance. Epidemics are analyzed to identify environmental and cultural factors that influence their severity. Isolates of the stem and leaf rust fungi are collected for analysis of intra- and interpopulation variation in virulence genes and molecular markers. This project also includes a study of phylogenetic relationships among populations of the leaf rust fungus specific to different wheat types and to alternate hosts in different plant families. The molecular genetics project focuses on determining the size and organization of wheat rust genomes, RFLP mapping, and developing methods to genetically transform obligately parasitic rust fungi.

Status of Research:
Many new genes for stem rust resistance were discovered in spelt wheats which can expand present resistance in bread wheat. Many other resistance genes were found in wild species with AABB genomes. The first generations of rust increase in juvenile wheat was found largely confined within small disease foci until sporulating infections occurred on the flag leaf or peduncle. Then rust spores were widely dispersed over the wheat canopy. This knowledge made it possible to distinguish long distance spread versus local buildup of rust during epidemics. Sites at which stem and leaf rust overwintered in winter wheat were found in the Dakotas. Overwintering of rust so far north appears to be a new phenomenon related to increased use of minimum tillage and furrow planting, which retain more snow cover and protect the wheat and rust from severe weather. The wheat stem rust population of the Great Plains consists of 9 isozyme phenotypes, each of which comprises a cluster of closely related virulence phenotypes. This pattern results from asexual reproduction and contrasts with that in the Pacific Northwest where virulence genes and isozyme phenotypes are randomly associated as expected from a sexual population. In the molecular genetics project, DNA reassociation kinetics revealed that the wheat stem rust fungus has a large genome (for a fungus) of 5.8×10^7 base pairs, of which 68% are in unique sequences. Reconstructions from serial EM sections of pachytene nuclei showed that the wheat stem rust fungus has $n = 18$ chromosomes of relatively uniform length. The GAPDH and HSP70 genes from the wheat stem rust fungus were cloned and sequenced. Their regulatory regions are being used in constructing transformation vectors. Also, highly expressed mRNAs were cloned from germinating urediniospores for use in isolating efficient promoters. Two cDNAs have been isolated; one is highly expressed in all rust stages and the other is sporulation specific.

Grain Crop Production and Quality
Research Review

Commodity: Wheat
Management Unit Representative: Merle G. Eversmeyer
Management Unit: Plant Science and Entomology
(SY = 3: Eversmeyer, Cox, Hatchett)
Location: Manhattan, Kansas

Objectives/Approach:

The primary objective of the wheat research group at Manhattan, KS is the development of multiple pest resistant wheat germplasm. The interrelated objectives and approaches of a Geneticist, Plant Pathologist, and Entomologist are: 1) To develop new and improved methods for wheat leaf rust control, which emphasize host plant resistance, host-parasite interactions and population dynamics by searching for germplasm sources to which the pathogen population is avirulent and continuing to elucidate the interaction of host-pathogens; 2) To develop new and improved methods for wheat insect control with emphasis on plant resistance by identifying new sources of Hessian fly resistance in wheat and related species, determining resistance and genetic mechanisms, and investigating the genetics of Hessian fly-wheat interactions; 3) To determine inheritance and factors affecting heritability of pest resistance in wheat and the development of multiple pest resistant germplasm adapted to the HRWW region through (a) evaluation of genetic diversity in wheat and progenitor species, (b) introgression of specific resistance genes from progenitor species and determination of their inheritance, (c) recurrent selection in random-mating populations segregating for male sterility and resistance genes; (d) introgression of germplasm en masse from diploid progenitors into the A and D genomes of elite wheats to broaden the genetic base, (e) investigations of prospects and methods for obtaining "durable" resistance in wheat; 4) To determine the ecology and epidemiology of wheat diseases and their interactions to develop pest control strategies by determining the biometeorological interrelationships operative in epidemic development and resulting loss in multiple disease epidemics. Develop models of multiple disease epidemics based on available biometeorological data.

Status of research:

Steady progress is being made in the incorporation of leaf rust resistance into wheat germplasm in the Great Plains. A continued increase in percent low infection types is noted in the breeding material. Several new sources of Hessian fly resistance have been identified in *Triticum tauschii, T. monococcum,* and *T. turgidum*. Resistance to Hessian fly in rye is seen as a potential source to be transferred to wheat by x-ray and somaclonal-induced chromosomal translocation. Different resistance genes transferred from the diploid species vary greatly in expression. We have germplasm with Hessian fly, soilborne and spindle-streak mosaic viruses, powdery mildew, and leaf and stem rust resistance released or near release. The first molecular map of a wheat species (*A. squarrosa*) was produced. The ability of one *T. monococcum* strain to produce female-fertile F_1 hybrids with wheat will provide a "bridge" to extract useful genes from noncrossable *T. monococcums*. Preliminary models of multiple disease loss assessment indicate forecasts can be developed from National Weather Service data.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Wheat

Management Unit Representative: Kenneth P. Vogel

Management Unit: Wheat, Sorghum, and Forage Research Unit

Location: Lincoln, Nebraska

Objectives/Approach:

Research is focused in two areas: genetic improvement of winter wheat quality and development of wheats resistant to viruses. Genetic research on quality combines conventional and molecular investigations on the inheritance of specific proteins and protein subunits, their stability over environments, and their effect on wheat products. Molecular mechanisms for interaction between viruses, vectors and host plants, particularly wheat are being investigated with emphasis on the interaction of virus replication, gene expression, and gene regulation with host plants. Goals are to develop improved wheats with specific end-market uses and transgenic wheats resistant to virus diseases.

Status or Research:

Wheat quality: The first comprehensive analyses of the extent to which high and low molecular weight glutenin subunit variation contributed to genotypic differences in hard, red winter wheats (HRWW) was determined. Conducted comparative analyses of 1AL/1RS and 1BL/1RS translocations in common genetic backgrounds; verified the quality advantages of 1AL/1RS over 1BL/1RS; and identified 1AL/1RS and 1BL/1RS wheat-rye translocation lines with improved quality. Developed a unique high protein, high quality line, N86L177, that is being proposed for variety release in 1991. Demonstrated significant influences of genotype by environment interaction effects on end-use quality and variation in varietal stability over environments for end-use quality.

Wheat viruses: Based on immunoelectron microscopy of virus and virus/host interactions, a hypothesis was formulated that a potyvirus-coded protein promotes cell to cell movement of potyviruses. Transgenic plants expressing the putative movement protein will be generated to test the hypothesis. A fungal vector has been used to transmit the bacterial enzyme chloramphenicol acetyl transferase to wheat roots and the enzyme was transiently expressed. This approach will be used in attempts to transform wheat embryos. A polymerase chain reaction (PCR) protocol and primer set was developed which allows rapid and sensitive detection of barley yellow dwarf virus and every luteovirus tested to date. Assay does not require antisera or cDNA.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Wheat
Management Unit Representative: John Roberts
Management Unit: Regional Plant Introduction Unit
Location: Griffin, GA

Objectives/Approach: The objectives are to reduce losses in small grain yield and quality due to cereal rusts. Specifically, this will be done through: a) Virulence and epiphytotic surveys as part of the National Cereal Rust Laboratory research to provide early warning of developing rust epidemics and evaluate currently deployed genes for resistance. b) Research to develop rapid, cost effective means to detect rust overwintering and evaluate epidemic development. Utilize remote sensing and other techniques to supplement existing surveys. c) Develop rust-resistant germplasm with diverse types of resistance to benefit breeding programs throughout the Southeast. d) Conduct expanded research on the role of epicuticular waxes in infection by cereal rusts. Investigate means to limit or alter leaf wax components chemically and genetically in order to restrict the infection enhancing benefits derived by rusts from waxes. Continue research on the effects of leaf pubescence on infection by cereal rusts.

Status of Research: Cereal rust epidemiology research and virulence surveys over the past seven years have contributed to an expanded knowledge of the spread of wheat leaf rust from the Gulf Coast in late winter to the Ohio Valley in early June. New leaf rust virulences rapidly appear and predominate throughout the Southeast in reponse to deployment of new sources of resistance, limiting the life of new cultivars to as little as four seasons. Timely virulence monitoring has enabled breeders to use new sources of resistance soon enough to replace cultivars in response to virulence population changes. A survey technique utilizing the interstate highway system to facilitate access to rust trap plots has provided enough data to indicate the technique can effectively detect rust and provide virulence information to supplement standard surveys. The first season using the Interstate highway nursery survey technique during the normal growing season to compare oversummering sampling with regular season rust occurrence has been completed, providing several rust collections to augment regular survey data. Early surveys in the deep South are designed to detect patterns of rust spread and new virulence combinations early in the season to enable some prediction of probable rust hot spots and cultivar vulnerability. Additional compounds which block the leaf rust germ tube's ability to utilize epicuticular waxes during infection may offer a safe source from which to develop a fungicide for leaf rust control. Blocking this capacity has been shown to reduce infection by 27%. Wheat leaf pubescence also has an important effect on leaf rust infection. Interference of normal growth is evidenced by erractic germ tube behaviour when contacting leaf hairs. Such disruption offers another means to reduce damage from rusts. Germplasm development and release plans continue to include the completion of the release of six germplasm lines and extended crossing to incorporate several new sources of reisistance and combinations of resisance genes into modern types. These resistances have not been used in this country as yet and should provide significant protection from rust.

GRAIN CROP PRODUCTION AND QUALITY RESEARCH REVIEW

Commodity: Wheat
Management Unit Representative: Roger Ratcliffe
Location: West Lafayette, Indiana

Objectives / Approach:

Objectives of entomological research are related to development of improved insect resistance in wheat, especially to the Hessian fly. Objectives are: To identify and release new genetic sources of resistance; to investigate the genetics of Hessian fly biotypes virulent to resistance genes in wheat; and to investigate the biochemical/molecular basis for resistance to the Hessian fly. Approaches include: 1. Evaluation of germplasm from NSGC and material developed at Purdue and other locations by using standard laboratory, greenhouse, and field procedures. 2. Release of publicly-developed germplasm in Indiana in cooperation with Purdue University. 3. Determination of Hessian fly biotype composition in the Eastern U.S. to aid breeders in the deployment of resistance genes in locally adapted germplasm. 4. Investigation of the genetics of Hessian fly biotypes to determine the interrelationship of genes for virulence in the insect to resistance genes in the host. 5. Characterization of enzymes used by Hessian fly larvae in feeding, and identification of morphological and chemical changes in susceptible and resistant plants due to infestation. 6. Use of heterologous probes to identify genes in wheat that may function in resistance, and to determine genetic differences among Hessian fly biotypes.

Status of Research:

In 1989-90 over 26,000 breeder lines were screened for resistance to six Hessian fly biotypes. Thirty entries from SAES and private wheat breeders were evaluated in Uniform Hessian Fly Nursery trials in seven states. Field surveys in 20 states identified 14 of the possible 16 Hessian fly biotypes present, with biotypes B, D, J, and L the most frequent. Wheat genes H10, H11, and H15 appear to be ineffective because of natural virulence in the field.

Hessian fly larval feeding significantly reduced stem number, plant and crown weight and soluble crown carbohydrates in susceptible, but not resistant wheat. Analysis of plant proteins indicated changes occurred in both susceptible and resistant plants due to infestation. Proteins appearing early in the infestation of resistant plants did not appear in susceptible plants. Low copy and unique clones were obtained from a Hessian fly genomic library and used in identifying RFLPs among biotypes. In situ hybridization was used to determine the location on polytene chromosomes of clones showing polymorphisms among biotypes.

SOFT WHEAT QUALITY LABORATORY RESEARCH REVIEW

P. L. Finney, Wooster, OH

GENERAL LABORATORY OBJECTIVES ARE TO: I) DETERMINE AND PREDICT IMPORTANT MILLING AND END USE PROPERTIES; and II) INSURE THAT QUALITY OF NEW WHEAT RELEASES EQUALS OR BETTERS COMMERCIAL CULTIVARS. SPECIFIC OBJECTIVES are to: enumerate the major flour quality parameters which influence cookie and cracker texture; improve experimental baking tests so that they better relate to commercial production; refine & develop new analytical methods, screening procedures, and predictive milling and end use tests; develop a bar code automated data collection system and connect laboratory balances to hand-held computers; demonstrate parameters which influence wheat test weight and develop replacement options; refine & develop new methodologies to measure wheat kernel density, shrivelling, size, and pericarp condition; and elucidate the roles that the gross and minor starch and protein fractions play in cookie or cracker quality. **THE BASIC LABORATORY APPROACHES ARE TO DISTINGUISH AND ELUCIDATE THE EFFECTS OF SOFT WHEAT GENETICS AND ENVIRONMENT ON SOFT WHEAT AND FLOUR PHYSICS, CHEMISTRY, DOUGH RHEOLOGY, AND PRODUCT QUALITY AS DETECTED BY SUBJECTIVE AND OBJECTIVE TESTS.** Using a **three-pronged approach**, we will: 1) generate analytical, milling and baking data; 2) refine objective measurements, such as Instron 3-point break-, resistance to grinding-, and punch-methods, and relate them to subjective, organoleptic measurements; and 3) improve fractionation-reconstitution, fraction-interchange, and innovative bake tests, and use them to determine flour component contribution to end product quality. In addition, NIR or other means will be used to differentiate kernel density, size, shrivelling, sprout level, and field history. Effects of flour protein quality and quantity on milling and end use quality will be elucidated. Differences in starch fraction composition will be studied in connection to end product texture. Effects of salts and metal-complexing agents on gluten will be studied. Electrophoretic or other procedures will be refined or developed to separate enzymes and isoenzymes which will be investigated with respect to relevance to milling and baking behavior.

RESEARCH STATUS:

Historically two conditions have limited soft wheat research and evaluation success relating genetics x environment to milling and end product quality: 1) experimental bake tests have inadequately related to commercial production; and 2) objective texture measurements have not been based on sound materials measurement techniques and have not corroborated expensive and tedious organoleptic studies. Preliminary research at the SWQL and cooperative funded projects with the soft wheat baking industry indicate that both research conditions have now been reasonably well met. In addition to flour particle size and water holding capacity, protein quality and quantity significantly impact texture of various cookie and cracker products. The physicochemical, biochemical and rheological bases for those and other perceived differences will be investigated.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Wheat

Management Unit Representative: Jerold A. Bietz

Management Unit: Food Quality and Safety Research

Location: National Center for Agricultural Utilization Research, Peoria, IL

Objectives/Approach:

Our goals include: (1) Improve wheat varietal development, marketing, and utilization through better knowledge of gluten proteins. Analytical methods, including narrow-bore high-performance liquid chromatography (HPLC) and capillary electrophoresis, will yield rapid routine methods of varietal identification, classification, mixture analysis, quality control, selection during breeding, germplasm analysis, and plant varietal protection for hard, soft, and durum wheats. (2) Optimize multivariate statistical methods to objectively interpret complex data from wheat protein analysis. Develop routine methods to identify proteins associated with breadmaking or kernel quality, and which vary with environment. Refine understanding of protein allelic "blocks" related to quality and agronomic characteristics. (3) Determine effects of denaturation, detergents, temperature, and processing on sizes, solubilities, conformations, interactions, and functionality of native and processed gluten proteins. Analyze protein aggregation in thermally processed grains and grain products. (4) Relate vital wheat gluten structure, quality, and functionality to wheat type (hard, soft, or by-products), and define processing parameters, such as drying conditions, to optimize gluten production and quality. Explore new food and non-food uses of native and modified gluten.

Status of Research:

In CWU 3620-4100-007 ("Proteins from Diverse Wheat Germplasms Related to Breadmaking Quality and Utilization"), reversed-phase and size-exclusion HPLC were used extensively to relate qualitative and quantitative compositions of gliadin and glutenin proteins to environment, agronomic factors, genotype, stage of development, hardness, and quality of wheat. Statistical techniques helped identify proteins related to mixing and baking quality, hardness, pedigree, and class. Methods of varietal identification were improved, and biotypes analyzed. Results showed how protein amounts vary within genotypes, and aided in varietal identification. Hard/soft and spring/winter wheats were milled and air-classified; particle size distributions related to hardness and class. Air classification of wheat flour yielded useful high protein fractions, and separated small from large starch granules. A hardness test was devised based upon grinding time. Gluten heat denaturation and glass transition temperature were probed by differential scanning calorimetry; gluten exhibits classical polymer behavior. Acceptable spaghetti was prepared with 10% corn distillers' grains. HPLC of rice, rye, triticale, and barley proteins also permitted varietal identification, characterized the development of these grains, and aided in breeding.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Wheat

Management Unit Representative: Okkyung Kim Chung

Management Unit: Grain Quality and Structure Research Unit

Location: Manhattan, Kansas

Objective/Approach:

One of the three CRIS units in the Grain Quality & Structure Research Unit is traditionally known as Hard Winter Wheat Quality Laboratory (HWWQL). The main objectives of the HWWQL are: (a) to evaluate functional properties (milling, dough rheology, and baking) of the breeders' wheat progenies with an emphasis on quality improvement of the U.S. wheat cultivars; (b) to develop and/or improve testing methods; (c) to investigate biochemical components responsible for certain quality factors; and (d) to serve as a communication and/or information media bridging between wheat product industry and wheat breeders. Research projects of the MU on wheat quality include: 1. Determination of hardness and gluten quality of wheats (experimental and commercial lines) using NIR and Glutomatic Systems, respectively, to differentiate wheat classes (hard vs soft and winter vs spring), predict functional properties, and study the environmental effects on those properties. 2. Wheat varietal identification. 3. Determination of electrophoretic and/or chromatographic properties of wheat proteins that discriminate between good and poor quality. 4. Hard red spring (HRS) and hard red winter (HRW) wheats grown in the same location.
5. Development of methodology to analyze starch granule formation in maturing wheat endosperm. 6. Mechanism of storage protein synthesis and deposition in wheat endosperm as it relates to grain hardness.

We are now capable of detecting and measuring starch granules down to about 2 μm in diameter which is at the limit of resolution of the video camera at the magnification used to photograph the starch.

Status of Research:

Evaluation of breeders' samples will continue. Recently, testing parameters were expanded to include NIR hardness values, kernel sizing, flour color, and Glutomatic data, etc. We will continue to collect data for NIR hardness, gluten quality, full scans of NIR, functional properties (milling, dough, and baking characteristics), and environmental information of wheat growing locations.

In the last 5-10 years, many of the new varieties released were very difficult to identify by visual physical characteristics. The only way to identify them quickly is to biochemically characterize the protein patterns. The use of biochemical methods to identify varieties is used more and more for varietal discrimination. We have used high performance liquid chromatography (HPLC) and polyacrylamide gel electrophoresis (PAGE) with lactic acid at pH 3.1 (A-PAGE) and with sodium dodecylsulfate (SDS), SDS-PAGE, to characterize cereal proteins and identify varieties. HPLC and electrophoretic patterns of gliadin (G) and glutenins (GN) extracted from a pair of sister lines, with different bread-making qualities, showed differences in the omega- and beta-G region and in the GN high molecular weight (HMW) region. Baking quality differences were attributed to the deletion of the 1D chromosome, which codes for the omega-G and group 5 + 10 GN HMW subunits. The effect of HMW-GN genes on the baking quality of a diverse hard winter wheat population was determined. GN-based selection for increased mixing time and tolerance gave lower predicted gains than phenotypic selection. HPLC was used to quickly (15 min) identify wheat lines containing the rye translocation (1BL/1RS). Presence of 1BL/1RS improves disease resistance and yield but has been associated with sticky doughs. Functional properties were quite similar between the HRS and HRW wheats grown in the same location except for the kernel hardness. HRS wheats were harder than HRW by about 20 units. HPLC analysis of gliadins revealed no unique proteins present or absent in either class that could be used to accurately determine winter or spring class. However, statistical analysis of the gliadin chromatographic data showed that the spring wheats were clustered in a tight group whereas the winter wheats were not. Early results from comparisons of soft and hard wheat indicate that there are differences in starch distribution profiles between hard and soft wheats. Finally, for the mechanism of storage protein synthesis, we use immunocytochemical techniques to localize specific classes of storage proteins during their synthesis and deposition. Use specific inhibitors of protein deposition to determine modes of transport.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Wheat

Management Unit Representative: J. L. Steele & C. R. Martin

Management Unit: Engineering Research Unit, USGMRL

Location: Manhattan, KS

Objectives / Approach:

Select and develop a methodology to determine hardness and moisture content of single wheat kernels.

Develop procedures and instrumentation to implement the methodology and rapidly feed and characterize single wheat kernels.

Transfer the technology developed to the wheat industry by adoption in market channels and commercial production of the instrument.

Status of Research:

In the last 3-4 years, an instrument to rapidly feed single wheat kernels and determine crush force and conductance data was developed and evaluated at several stages of its development. Four prototype instruments were delivered to FGIS for evaluation on March 8, 1989. These instruments processed 180 kernels per minute and had a classing index of about 1.2 based on the reference samples used to standardize hardness calibrations. To achieve this level of performance, a data processing or smoothing procedure was used to reduce kernel to kernel variation. This procedure was viewed as unacceptable when processing samples of mixed hardness. In an attempt to further understand the crush force profiles and reduce kernel to kernel variation, a study was conducted to determine the effect of kernel weight and size on the classification performance of the instrument. For the FGIS hardness reference samples (17), weight and size of 300 kernels of each sample were determined. The weight of each kernel was determined manually while the size data for each kernel was determined by two projection video images. The inclusion of either kernel weight or two accurate kernel dimensions in the hardness algorithm significantly improved the classification performance (1.55) while the inclusion of both weight and size in the hardness algorithm did not produce a higher level of classification performance. As a result, a single kernel weigher or certain size measurements of each kernel was needed. After some investigation of the instrumentation requirements for either weight or certain size measurements, a single kernel weigher was developed and incorporated into the instrument. Kernel throughput rate was reduced to 90 kernels per minute to accommodate inclusion of the weigher and additional data processing needed to derive a set of improved hardness parameters. Inclusion of the weighing device improved the classing index (without smoothing) from 1.1 to 1.5. Three instruments were equipped with the weighing device and calibrated using the FGIS hardness reference samples conditioned to three moisture levels. Two instruments were delivered to FGIS for evaluation on Nov. 29, 1990. Initial evaluation and testing of samples mixed in hardness was completed by FGIS. FGIS is currently running the 1990 field survey samples (approx. 12,000). ARS efforts are currently directed toward instrument refinements, temperature sensitivity analysis, patent processing and selection and licensing of a commercial firm for production of two commercial prototypes.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Wheat

Management Unit Representative: J. L. Steele

Management Unit: Engineering Research Unit, USGMRL

Location: Manhattan, KS

Objectives / Approach:

Develop equations of motion for the mixograph moving pins and simulate the motion, velocity and drag forces associated with movement in a uniform viscous liquid.

Based on the simulated results, determine appropriate instrumentation methods to instrument a mixograph for digital acquisition of both moving and fixed bowl mixograms on the same mixograph.

Calibrate the instrumented mixograph so that the acquired moving and fixed bowl data can be converted to torque and quantify apparent differences in typical torque vs. time mixograms.

Instrument additional mixographs, provide calibration equipment and develop digital acquisition software for the wheat quality laboratories and studies at USGMRL, Pullman, WA and Peoria, IL.

Determine equations of motion and bowl platform dynamics to resolve the apparent differences in typical moving and fixed bowl mixograms.

Status of Research:

Equations which express moving pin positions, velocities and drag forces in a uniform viscous liquid in terms of input shaft rotation angle were developed and implemented for personal computer simulation. The simulations revealed the instrument cycle and basic torque sub-cycles which are imposed on the fixed or moving bowl platform. Careful torque calibrations revealed nearly equal energy transfer to the bowl platform for both the moving and fixed bowl mixograms. This was not readily obvious since the torque fluctuations for the fixed bowl were consistently larger and frequently approach zero throughout the mixogram. For the fixed bowl method, the torque peaks were synchronized throughout the mixogram at the pin position referred to as "hurdling". Because of platform dynamics, this was not true for the moving bowl mixograms. Through study of the platform and instrumentation dynamics for both methods, the moving and fixed bowl mixograms can be translated to reflect the forces actually imposed on the platform by the dough. It is hypothesized that these forces will be more nearly identical and appropriate for comparison of the two instrumentation methods. Development and simulation of the equation of motion and dynamics of the platform is underway. Installation of instrumentation on mixographs for the quality laboratories is nearly complete.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Wheat

Management Unit Representative: J. L. Steele

Management Unit: Engineering Research Unit, USGMRL

Location: Manhattan, KS

Objectives / Approach:

Investigate the potential and reliability of single slice cross-sectional area measurements determined by digital image processing to predict loaf volume as measured by current bake-lab procedures.

Investigate the potential and reliability of multiple slice cross-sectional area measurements determined by digital image processing to predict loaf volume as measured by current bake-lab procedures.

Investigate other digital image and analysis techniques to accurately determine the volume of imaged objects.

Determine baked loaf crumb grain and texture using digital image analysis and correlate with current baked loaf scores by experts.

Combine objective crumb grain with other standardized baked loaf quality measurements and develop a complete automated baked loaf quality evaluation system.

Status of Research:

Research and development on the potential for objective evaluations of baked loaf quality is just beginning. The first objective will be addressed in a research apprenticeship project during the summer of 1991. Progress on the remaining objectives is expected to follow completion of that study.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Cereal Grains (Oats, Barley, Rice, Wheat)
Management Unit Representative: Antoinette A. Betschart
Management Unit: Food Quality Research Unit
Location: WRRC, Albany, CA

CWU 5325-52000-001-00D Improving the Nutritional and Health Promoting Properties of Cereal Foods.

Objectives / Approach:

1. Identify compounds in cereal grains which reduce risk factors for chronic diseases and/or obesity.
2. Determine processing conditions which concentrate and maintain the physiological activity of these components.
3. Develop prototype value-added cereal products which contain these components and reduce risk factors associated with chronic disease (i.e., reduce rate of carbohydrate digestion and lower serum LDL cholesterol).

Specific botanical components and macronutrients will be studied in wheat, rice, oats and barley. Cereal brans, starch, fiber, and lipid rich fractions and sub-fractions will be evaluated for their effect on cholesterol status and rate of carbohydrate digestion. Processing parameters such as extrusion, baking, toasting, boiling, and microwave cooking will be evaluated in terms of retention of physiological activity. *In vitro*, small animal, and selected human studies will be conducted to determine the relative efficacy of cereal grain fractions and the impact of processing procedures.

Status of Research:
Methods have been developed to concentrate fractions of oat and barley grains which are rich in beta glucans. These beta glucan rich fractions are being tested in feeding experiments with hamsters along with fractions from rice bran, rice bran oil, and wheat to find the effect on cholesterol status. The influence of fractions from these grains on the rate of digestibility is also being tested by *in vitro* methods. Baked products have been formulated which double total dietary fiber and reduce calories 10-15% relative to a control while retaining consumer acceptability.

CWU 5325-41000-018-00D Development and Control of Quality Factors in New Cereal-Based Extruded Foods.

Objectives / Approach:
Production of shelf stable "snack" type foods from a mixture of cereal grain, fruits, and vegetables with a twin screw extruder. Factors which influence texture, appearance, taste, porosity, and nutrient retention will be studied in order to control product quality.

Status of Research:
Unbleached soft wheat flour was extruded with additions of fruit juice or vegetables to adjust flavor and color to the products. Various parameters of extruder operation were altered to change energy input and product density was found to be inversely proportional to energy input.

GRAIN CROP PRODUCTION AND QUALITY RESEARCH REVIEW

Commodity: Wheat, Oats, Barley
Management Unit Representative: Stewart M. Gray
Management Unit: Plant Protection Research Unit
Location: Ithaca, New York
Objectives / Approach: The barley yellow dwarf virus (BYDV) program at Ithaca has two interrelated objectives: (1) to define the mechanisms of vector specific transmission of the viruses that cause barley yellow dwarf disease, (2) to investigate the mechanisms and epidemiological significance of plant resistance to BYDV and aphid vectors.

Vector specific transmission of BYDV involves the recognition of virus structural proteins by membrane receptors in the aphid salivary gland. Nontransmissible isolates of BYDV are acquired by any aphid, but are excluded from the salivary gland and therefore not inoculated into the plant. The biologically active regions of virus structural proteins are being identified by monoclonal antibodies that neutralize transport of the virus through the salivary gland membrane. Antigenic domains are mapped using a series of in vivo generated peptides representing overlapping regions of the viral structural proteins. Virus receptors present on aphid salivary gland membranes are being localized in immuno-electron microscopy studies utilizing anti-receptor antibodies and anti-receptor peptides.

Cereal genotypes are being evaluated for resistance to BYDV and aphid vectors. Currently spring oats are being utilized as the model plant system. Selection criteria include symptom expression, virus titer, yield components, and aphid transmission to and from the plant. The general mechanisms of virus resistance (e.g. reduced titer, localized distribution) are identified and evaluated in the laboratory and greenhouse as to their effects on virus transmission by aphids. The epidemiological significance of the various types of resistance mechanisms are then evaluated in field trials.

Status of Research: Ten monoclonal antibodies have been evaluated for their ability to neutralize virus transport in the aphid. Four antibodies inhibit transmission of one or more BYDV isolates. An additional 35 monoclonal antibodies are in various stages of characterization as to their specificity in binding to the NY isolates of BYDV and their ability to neutralize virus transport. Anti-idiotypic antibodies have been produced to 3 neutralizing monoclonal antibodies and are being tested for their ability to bind to membrane receptors. In addition, the capsid protein gene from two BYDV isolates has been cloned. Subclones have been used to produce, in a bacterial expression system, a series of overlapping peptides representing the entire capsid protein for both BYDV isolates. Using immunoblotting techniques the binding domains of 3 monoclonal antibodies have been identified.

A type of resistance manifested as a suppression of BYDV titer, measured by ELISA, was identified in a breeding line of oats (IL86-5262). Mean level of titer suppression, relative to a susceptible oat genotype ('Astro'), for 6 wks post-inoculation was 80%, 65%, 61%, 58%, and 3% for the RMV, PAV, MAV, SGV, and RPV isolates of BYDV, respectively. Transmission efficiency of PAV, MAV and SGV by single aphids was lower from the resistant tissue relative to susceptible tissue, but remained above 70%. Transmission efficiency of RMV dropped from >80% to <40%. In field trials, the incidence of RMV reached 90% in susceptible 'Astro' plots, but remained <1% in IL86-5262 plots despite heavy inoculum and vector pressure. Final disease incidence of the MAV isolate was 74% and 97% in resistant and susceptible plots, respectively. The resistance in IL86-5262 is BYDV isolate specific and emphasizes the need to use multiple isolates when screening for resistance.

Grain Crop Production and Quality

Research Review

Commodity: Wheat and Barley

Management Unit Representative: R. James Cook

Management Unit: Root Disease and Biological Control Research Unit

Location: Pullman, Washington

Objectives/Approach:

Our research program is focused on control of the root diseases of wheat and barley in the Pacific Northwest and has three objectives: 1) To improve our understanding of the etiology and the epidemiology of wheat and barley root diseases; 2) to improve our understanding of the ecology and molecular biology of natural biological control in the rhizosphere of wheat and barley, and 3) to develop practical biological controls of wheat and barley root diseases effective in modern farming systems. Objective 1 involves a standard approach to understanding root disease etiology and epidemiology, including identification of causal organisms and understanding disease development in relation to environmental and cultural practices. Objective 2 is aimed at finding microbial biocontrol germplasm and understanding mechanisms of control of the root diseases by microorganisms with ability to team up with the root and express the equivalent of disease resistance. Objective 3 is aimed at practical application of root-associated microorganisms alone on in combination with improved agronomic practices for root disease control in fields managed with conservation tillage.

Status of Research:

We have shown that the increased growth response of wheat to soil fumigation and previously interpreted as a response to increased soil fertility is the direct result of elimination of root pathogens and hence increased efficiency of uptake of nutrients by healthier roots. We have also shown that the disappointingly poor performance of wheat and barley planted into wheat or barley residue (conservation tillage) and long attributed to putative phytotoxins from rotting straw is also the result of root diseases in response to both the more favorable soil moisture for the activity of root pathogens in soil covered with straw and the lack of crop rotation. The average increase yield of winter wheat in response to soil fumigation in commercial fields over a 15-year period has been 70, 22, and 7%, respectively, in fields cropped every year, every other year, and every third year to wheat. We have identified take-all caused by *Gaeumannomyces graminis*, Pythium root rot caused by several *Pythium* species, and Rhizoctonia root rot caused by *R. solani* AG8 and *R. oryzae*. Soil fumigation is not an option, and the climate and soils of the region are highly suitable for wheat and barley at least every other year or two years in three. These root diseases must be controlled to increase fertilizer-use efficiency, open the way for conservation tillage, and permit more frequent cropping to small grains.

We have found "resistance" to take-all in strains of *Pseudomonas* that become associated with root of wheat after several successive outbreaks of the disease. Other strains have shown activity against Pythium root rot. The mechanism of take-all suppression by two strains studied in detail involves production of phenazine antibiotics, but other strains of bacteria produce other antibiotics. The reservoir of potentially useful microbial germplasm in some soils is virtually unlimited. Genes for phenazine biosynthesis have been cloned and expressed in other bacteria. Our goal is to use the bacterial delivery system with improved strains and strain combinations customized for soils and management systems.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Wheat, Oats, and Barley

Management Unit Representative: Adrianna Hewings

Management Unit: Crop Protection Research Unit

Location: Urbana, Illinois

Objectives / Approach:

The cereal virus group at Urbana has three interrelated objectives: To investigate mechanisms of resistance to barley yellow dwarf virus (BYDV), soilborne wheat mosaic virus (SBWMV) and other economically important cereal viruses; to investigate the dynamics of cereal virus epidemiology; and to evaluate the response of cereal germplasm to economically important viruses and cooperate in cereal germplasm enhancement programs. Projects on wheat include: 1. Determination of the effects of within-field virus sources on the intrafield spread of BYDV and the effects of aphid establishment and reproduction on the intrafield spread of BYDV. The research is focused on the relative importance of initial infection foci and early infestations of the aphid vector, *Rhopalosiphum padi* on virus spread in field plots. 2. Determination of the effects of different cultivars, vector species, and BYDV strains, on transmission efficiency as it relates to age of infection in source plants and vector infectivity, and plant age at inoculation and vector infectivity. 3. Evaluation of germplasm from the NSGC and material developed at Illinois and at other locations using a system of paired hills separated with spreader rows and artificial inoculation. Entries are evaluated for response to BYDV with the objective of identifying and developing material with good agronomic characteristics combined with sources of resistance to BYDV. 4. Determination of the incidence of soilborne wheat mosaic virus (SBWMV) before and after dormancy in susceptible and resistant winter wheat in an infested field and the effects of host growth stage and soil moisture on infection rates in controlled greenhouse studies.

Status of Research:

Data from 1989 and preliminary data from 1990 indicate that BYDV spread occurred more rapidly in fields where infection foci were established prior to aphid infestation. Suction traps were used to capture live aphids crossing the fields at canopy level. The first aphids to enter the traps occurred one calendar day later in 1989 than in 1990 but the first large aphid flight occurred almost two weeks later in 1989 than in 1990. *R. padi,* vector of both the BYDV-PAV and -RPV strains was captured with the greatest frequency and the PAV strain was transmitted by over 90% of the infective vectors. Results of two years of surveying wheat for BYDV has been completed and is reported in the section on oats from Urbana.

The incidence of detectable SBWMV in resistant roots was significantly lower than in susceptible roots the entire growing season; detectable virus in shoots was the same for all plants (100%) until after dormancy when the incidence dropped significantly in resistant plants. SBWMV infections did not occur in the spring. cDNA probes to SBWMV have been constructed and are in use to make + and - sense RNA probes that will be used to measure the accumulation of virions and dsRNA in resistant and susceptible field plants.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Rice Quarantine Processing

Management Unit Representative: Bruce J. Parliman

Management Unit: National Germplasm Resources Laboratory, Plant Germplasm Quarantine Office

Location: Glenn Dale, Maryland

Objectives/Approach:

The Plant Germplasm Quarantine Office (PGQO) is a component of the National Plant Germplasm System and is service oriented. The PGQO has the responsibility for quarantine processing the seed of only one major grain crop, rice. The rice quarantine processing group at Glenn Dale has three interrelated objectives: To grow imported rice seed accessions through one life cycle under quarantine conditions and processing procedures; to capture/collect passport, range, and other germplasm-related data from imported rice consignments processed through the PGQO and other scientists holding quarantine processing permits and enter that data into the GRIN; to identify, label, and quarantine process the noxious weed species of rice Oryza longistaminata, O. punctata, and O. rufipogon. Seed and information enter the United States through the Animal and Plant Health Inspection Service - Plant Protection and Quarantine Inspection Station at Beltsville, Maryland where they are inspected visually and given a short hot water treatment. The responsibility for seed is then transferred to PGQO staff where data are collected and entered into the GRIN. Seed are dehulled and inspected for red bran color (characteristic of weedy species), surface sterilized, germinated under sterile conditions, and grown out under quarantine conditions. Mother plants are inspected by both PGQO and APHIS-PPQ staff for disease symptoms. Seeds produced on mother plants which have been inspected and found free of evidence of disease during the growing season are eligible for release from quarantine by APHIS-PPQ staff. Once released, PGQO staff distributes quarantine-released seed to requestors and to the National Small Grain Collection at Aberdeen, ID. Once receipt of accessions is ensured, PGQO destroys all remnant seed and remaining mother plants.

Status of Project

New quarantine processing procedures have been implemented fully by PGQO. An Operations Manual has been written. Communications between PGQO staff and members of the rice community have been enhanced and nurtured. No backlog exists for the quarantine/data processing of any current accession. New accessions complete quarantine processing procedures at PGQO usually within one growing season of the date of their arrival. Several hundred accessions at the National Small Grain Collection have been identified as never having been quarantine processed. The processing of these accessions is expected to be completed within the next 12 to 18 months. Annually, the PGQO has room to quarantine process approximately 300 rice accessions.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Sorghum

Management Unit Representative: A. Sotomayor-Rios

Management Unit: Tropical Crops and Germplasm Research

Location: Mayaguez, Puerto Rico

Objectives/Approach:

The cereal group at Mayaguez has the following objectives: Introduce, evaluate and introgress new germplasm of corn, sorghum and millet; transfer improved resistance into populations; develop new management system with superior cultivars; optimize production of cereals using a multidisciplinary team approach; conduct winter nursery activities in conjunction with ARS and State scientists; coordinate the Sorghum Conversion Program. Projects on sorghum include: 1) Sterilization of promising sorghums into four new cytoplasms. Research is focused on the search for new cytoplasmic-nuclear combinations. 2) Development of disease and insect resistant populations; development of new B lines; development of herbicide resistant populations; development of acid soil-tolerant populations. 3) Determination of the maintainer and restorer reactions of all converted lines with A1, A2 and A3 cytoplasms.

Status of Research:

Millo Blanco (MB), a local sorghum cultivar, was sterilized into four new cytoplasms in cooperation with K. F. Schertz. MB as a cultivar was recently released. Recent populations released cooperatively with the University of Georgia are PG11BR and GP9BR, (herbicide tolerant); GPP5BR (M-HF)C3 (anthracnose resistant); GTPP7R(H)C5 (foliar disease resistant); GPP4BR(H)C5 (acid soil tolerant). Rust resistant population PR6BR is in its final random mating cycle and will soon be released jointly with the University of Georgia. Technological information for commercial sorghum production in Puerto Rico was developed; hybrids with partial resistance to sorghum midge were identified. During winter season 1989-90, 5,341 accessions and seven populations were grown for ARS and State scientists. As part of the Sorghum Conversion Program, 110 F2's were sent to Chillicothe, Texas.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Barley
Management Unit Representative: Gerald G. Still
Management Unit: Plant Gene Expression Center
Location: Albany, California

Objective/Approach:
The Plant Gene Expression Center is by design a noncommodity research investigation dedicated to the application and development of the most modern biology, biochemistry and molecular biology to create new tools to identify, characterize, transfer and stably transform agriculturally important crop species.

The PGEC has had a stable transformation of monocotyledneous plants program since its beginning. Dr. Fromm and his colleagues successfully developed technology for the stable transformation of maize using microprojectile technology. Since Dr. Fromm's departure for the Monsanto Corporation, work has continued on the maize stable transformation project.

The Plant Gene Expression Center has an interest in moving the maize stable transformation technology to small grains. To this end, the Center has established a Consortium dedicating its efforts to the stable transformation of barley. Resources from the University of California, ARS's Aberdeen, Idaho laboratory, and a corporate partner have formed a Consortium within the Plant Gene Expression Center to focus their efforts on this problem. The objective is to develop a genetic engineering technology which will allow for the introduction of important traits into barley. We believe that microprojectile bombardment has the greatest potential for the introduction of foreign genes into barley. Microprojectile bombardment is preferable to protoplast transformation techniques in barley since, to date, successful plant regeneration of barley protoplast has not been reported. A critical component for the success of this program will be developing appropriate cell culture systems that are conducive to regeneration. A number are presently being assessed. Barley anther, or isolated microsporal cultures, is one potential approach. Morphogenic callus is an alternative source of tissue culture-derived material. Regenerable barley callus cultures have been initiated from a variety of tissue explant sources, including mature embryos, apical maristems, masocotyl tissue, leaf bases, and immature inflorescence. Suspension cultures, derived from embryogenic callus, may provide a tissue-source more amiable to bombardment and selection of transformants than embryogenic callus itself. Despite the well-documented reports of regeneration of plants from barley callus cultures, however, there are no reports of successful regeneration of phenotypically normal plants from callus-derived suspension cultures.

There is an array of already available selectable marker genes at the PGEC that can be used for barley transformation. All of the selectable marker genes, constructs and molecular biological materials provided by the Fromm-maize program, will be available and used in the barley program.

Status of Research:
In mid-May, Dr. Lemaux will relocate to U.C. Berkeley and the PGEC to take leadership of the Barley Transformation team. She will work with Ms. Rosalind Williams, Dr. Phil Bregitzer and others on the Barley Transformation team.

GRAIN CROP PRODUCTION AND QUALITY
RESEARCH REVIEW

Commodity: Sorghum

Management Unit: Germplasm Introduction and Research Unit

Location: Kingshill, St. Croix, US Virgin Islands

Objectives/Approach:

The Germplasm Introduction and Research Unit (GIRU) located at Kingshill, St. Croix, US Virgin Islands (formerly the St. Croix Federal Experiment Station), has as its main project the growout of quarantined plant germplasm for the National Plant Germplasm System. The specific objective is to receive, grow and evaluate under APHIS protocols prohibited tropical and subtropical plant introductions of such crops as sorghum, corn and rice for the NPGS. Activities related to sorghum include: planting 2,948 accessions during a three-year period to produce 1,563 kg of selfed seed. The selfed seed is returned for distribution to Mr. Gilbert Lovell, S-9 Coordinator, Regional Plant Introduction Station, Experiment, Georgia. A duplicate sample of each accession from the St. Croix quarantine program is kept at the USDA-ARS, Tropical Agriculture Research Station, Mayaguez, PR.

Status of Research: The St. Croix Station conducts annual disease surveys and records key descriptor data of each entry it receives for grain sorghum.

cc: K.F. Schertz

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